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REMOTE STORAGE

Railway Electrical Engineer

Volume IV **June, 1912—May, 1913**

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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Railway Shops.

Since about 1900 there has developed a tendency in shop design toward greater completeness and permanence of both structures and their equipment and the introduction of more scientific methods of management in their operation. More attention has been paid to the arrangement of departments internally and relatively in order that materials may progress in a straight line through the shops, thus facilitating production and reducing costs and keeping the rolling stock in service a larger percentage of the time.

Electrical devices of every sort have been very generally adopted in all new shops and so far as possible in old ones. This is especially true of shop lighting and in a lesser, but still a large, degree regarding electric motors, welders, heaters, drills and many other applications. The influence of the electric crane has probably been greater than any other single factor effecting the layout of the shops as a whole, and the use of electric motors for individual drive of machine tools has influenced the design of the buildings. And all of these things tend to make the modern railway shop a more pleasant place to work and a more efficient element in any railway organization.

The electrical departments of the American railways of today are rapidly coming to the front and receiving equal recognition with the other departments, as they should, and it is to their efforts in many cases that the extended introduction of electricity in shops as well as cars has been due. As to how well their work has been done, it is only necessary to visit the railway shops of the country to see that it has been first-class.

During the past twelve months this paper has been giving its readers a series of articles describing the leading railway shops of the country, paying more attention to the equipment than to the general arrangement. So many favorable comments have been received that it has been decided to continue these articles, but, giving more specific attention to the details of the electrical equipment than has been the case.

In the course of the special study given this subject by the editor of our shop section, so many points of general interest regarding the broader phases of the problem were learned that it was decided to give our readers some of the benefit gained. This has been attempted in the article on "The Planning and Equipping of Railway Shops" published in this issue. It is obviously impossible to do more than refer to some of the principal points in an article of this sort, but we believe this story will prove of interest to all who read it.

This article should be read in conjunction with the regular monthly story in our "Shop Section," describing the Beech Grove shops of the Big Four Railway, as the machine tool equipments for the various departments of a railway shop have been purposely omitted from the general story to reduce its length. Typical equipments for all departments will be found at the end of the Shop Section article.

New Type of Roundhouse Lighting.

The big new roundhouse of the C. & N. W. Ry. at Butler, Wis., contains a novel installation of roundhouse lighting that should interest both the electrical engineer in charge of the design of these systems and the roundhouse foremen who use them.

On account of the extremely corrosive action of the steamy smoke which usually pervades the roof zone of a roundhouse, it becomes very difficult to maintain the proper insulation of any electric lighting circuit placed in that zone. Accordingly there has been a gradual evolution in roundhouse lighting systems to the end that all wiring be removed entirely from this smoke zone of trouble.

The installation at the Butler roundhouse described on page 3 of this issue marks a big step in advance in that the lighting units themselves are placed well below the smoke zone. The circuit wiring on this installation, however, is placed inside the house just above the windows, and while this is far better than placing it among the roof trusses or even outside on the roof, a more permanent installation could be made by placing the main circuit wires entirely outside the building and individual lead in wires for each aisle be brought in conduit through the wall from a junction box placed outside under the eaves.

Such an installation on the Illinois Central Ry. was described in the June 1909 issue of the RAILWAY ELECTRICAL ENGINEER. In this installation the main circuit wires were placed well up under the eaves

on the outside of the building where they were well protected from the weather and sun.

It is, however, with particular reference to the lighting system rather than the wiring that this installation is of interest. By using this particular type of reflector a horizontally directed light instead of the usual light from above is obtained. And, contrary to what might be expected from two headlight reflectors projecting down one end and one at the other end of the aisle between pits, a very good general illumination in both the aisle between the engines and in the lane extending in front of the pits is obtained.

By mounting the reflector on a wedge shaped block so that the beams cross, the light from one reflector being directed at the motion parts of the engine on the opposite side of the aisle and vice versa, a more effective illumination could doubtless be obtained than with the radial line projection as employed in this installation.

Association News.

Semi-annual Convention.

The semi-annual convention of the Association will be held at Hotel Dennis, Atlantic City, N. J., at 10 a. m., June 14th.

Program of the meeting is as follows:

10 A. M.

Address of President.
Report of Secretary-Treasurer.
Unfinished Business.
New Business.
Progress report of Various Committees.

2 P. M.

Informal talk on Railway Shop Equipment, etc.
(A. I. Totten, General Electric Company.)
(F. H. Herzsch, Westinghouse Company.)
Informal talk, "U. S. Postal Car and Passenger Car Illumination."
(A. J. Sweet, Holophane Company.)
(L. Schepmoes, Safety Car Htg. & Ltg. Co.)
Informal talk, "Method of Axle Generator Control, Constant Current vs. Constant Potential"—"Haulage of Equipment."
(By Representatives of Axle Car Lighting Companies.)

This is going to be the best semi-annual convention we have ever held. There will undoubtedly be a large number of railroad men from all parts of the country present.

Remember "The Dennis" is our headquarters, and we hope that all Associate members as well as all Active members will register there as members of the "A. R. E. E."

Annual Proceedings Now Ready.

Secretary Andreucetti reports that the 1911 proceedings of the Association are now ready and have been mailed to all members not in arrears on their dues. If you didn't get yours, may be it is because he's waiting for you to cash in on 1911-1912 dues.

We think he is pretty hard hearted ourselves, but he says he needs the money.

Entertainment Program for Atlantic City Conventions.

J. W. Taylor, Secretary of the Master Mechanics Association and the Master Car Builders Association has given out the following details regarding the entertainment features of the Atlantic City Conventions.

Contrary to previous custom a charge of $1.00 will be made for each badge issued to the members of the M. C. B. Associaiton. No charge is made for badges of the M. M. Association, but it is understood that a proportionate part of the entertainment expenses will be born by the M. M. Treasurer.

Roller Chairs.

The free use of roller chairs have been dispensed with, but arrangements have been made so that coupon books will be provided at the following rates:

10 rides $2.50
20 rides 5.00

When tickets are used, the book covers will be redeemed when presented to the chair companies with a refund of 50c on each 10 ride book and $1.00 on each 20 ride book.

Entertainment.

The following entertainment features have been provided:

Wednesday, June 12.

10:30 a. m.—Orchestra concert on Million-dollar Pier.
3:30 p. m.—Orchestra concert on Million-dollar Pier.
9:00 p. m.—Social gathering and informal dancing, Marlborough-Blenheim hotel.

Thursday, June 13.

10:30 a. m.—Orchestra concert on Million-dollar Pier.
3:30 p. m.—Orchestra concert on Million-dollar Pier.
9:30 p. m.—Informal dancing on Million-dollar Pier.

Friday, June 14.

10:30 a. m.—Orchestra concert on Million-dollar Pier.
3:30 p. m.—Orchestra concert on Million-dollar Pier.
9:00 p. m.—Musical programme.

Saturday, June 15.

10:30 a. m.—Orchestra concert on Million-dollar Pier.
2:00 p. m.—Baseball; parade from Million-dollar Pier to street cars.
3:00 p. m.—Annual baseball game.
No scheduled entertainment in the evening.

Sunday, June 16.

No scheduled entertainment.

Some Exhibitors.

Following is a list of some of the exhibits which will be of interest to men in the electrical departments of railroads:

Consolidated Ry. Elec. Ltg. & Equip. Co., New York.
Duntley Keller Pneumatic Tool Co., Chicago.
Edison Storage Battery Co., Orange, N. J.
Electric Cont. & Mfg. Co., New York.
Electric Storage Battery Co., Philadelphia, Pa.
General Electric Co., Schenectady, N. Y.
General Railway Supply Co., Chicago.
Gold Car Htg. & Ltg. Co., New York.
Gould Coupler Co., New York.
Gould Storage Battery Co., New York.
Johns-Manville Co., H. W, New York.
Main Belting Co., Philadelphia, Pa.
Morgan Flexible Steam Joint Co., Louisville, Ky.
Mudge & Co., Burton W., Chicago.
Pennsylvania Flexible Metalic Tubing Co., New York.
Pyle National Elec. Headlight Co., Chicago.
Reliance Elec. & Engr. Co., Cleveland, Ohio.
Remy Elec. Co., Anderson, Ind.
Safety Car Htg. & Ltg. Co., New York.
Sprague Elec. Wks. of General Elec. Co., New York.
U. S. Ltg. & Htg. Co., Niagara Falls, N. Y.
Van Dorn & Dutton Co., Cleveland, Ohio.
Ward Equipment Co., New York.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh, Pa.

The Lighting of the Pullman Shops

DANIEL WOODHEAD

One of the most progressive and radical changes in the lighting of large shops since the advent of the tungsten lamp has been made by the Pullman Company of Chicago. The story of the lighting of this plant, embracing as it does practically every type of shop work from the finest detail work to that of heavy machine work, offers an opportunity for comparison, which probably will not be met in any other plant in the country.

The work here is so varied, as one can well imagine by merely looking at a Pullman car and remembering that the car, in its minutest detail, is a product of the Pullman Company, that a trip through the immense plant can well be compared to a trip through a manufacturing town, of varied industries.

While a great proportion of the change was made on past experience, still a great deal of it was made on theory, the object of this installation being two-fold; to better the lighting conditions and to reduce the cost of lighting.

Previous to the present installation, the plants of the Pullman Company had been illuminated with variegated types of lighting units passing in range from the modern flaming arc to the most antiquated enclosed arc; gas arcs and carbon incandescent lamps; there was hardly a type of arc lamp which has been produced in the past fifteen years, that could not be found at some point in the plant.

There were in operation at that time, in round numbers, 800 arc lamps. To keep these arc lamps in operation required the constant services of four men whose duty was to trim and keep in repair, the lamps. The labor required for the up-keep of these lamps was a small item as compared with the actual cost of maintenance, such cost including repair parts and carbon; add to this the annoyance due to the uncertainty of life of the arc lamp, inefficiency of the lamp and the glare consequent upon the use of Carbon Lamps, and some idea of the conditions may be imagined.

After giving the problem thorough study in all its different phases, it was decided to adopt a permanent and standard system of lighting; thus, at one sweep, the entire expense and annoyance consequent upon an installation as described, was removed and in its place was substituted, an up-to-date system, thoroughly efficient, at a less cost, and with tremendous saving. The unit chosen as a standard, was the Columbia Mazda Lamp with a Benjamin Reflector.

Fig. 1. Showing Interior of Machine Shop.

In bettering the lighting conditions, light of ample intensity and of a quality suited for the work to be done, was desired. This work varied through a wide range so that each shop or department offered a specific problem in illumination by itself.

Fig. 1 Which shows the Machine Shop, gives some idea of the condition under which the work was carried out. In this case, a combination of general and local lighting was in order on account of the ceiling shafting and a great number of machines. Under such conditions, it would be impossible to light a machine shop evenly or with any degree of satisfaction without the use of drop lights. The average light intensity here is about 1 foot candle; the machines are provided with local drop lights, but not all are used, this depending a great deal on the operator and his relative position to the lighting unit. If he happens to be so situated that his machine is within range of the unit, no drop light is required.

The "Six Spindle Drill" shown in the center of the illustration, is lighted entirely by the unit directly above it, no other lighting being required. This is, perhaps, one of the best illustrations on record of the ability of the tungsten lamp to withstand jars and vibration. The lamp here shown, is the one which was originally placed in the unit in May, 1911, and is, "still in service and doing well." The reason for this lamp being placed in this position is the high intensity of light and even illumination required at that particular point. It can be readily seen that a series of drop lights on such a machine would be of great disadvantage to the operator.

The main runway with crane and trucking tracks as shown in Fig. 1 are lighted by 250-watt units; ample light is given here for the moving about of machinery and materials. At still other points in the shop, units are placed with reference to the machinery in an endeavor to do away with drop lights.

Fig. 6 shows a section of the Brass Shop as an example of still a different type of lighting. Here, there is also a small amount of overhead shafting, but a higher ceiling and at the same time more open space, so that much better opportunity is given for general lighting rather than a field for combining local and general lighting.

The Brass Finishing Room is a modern building with ample provision for natural daylight, there being windows on three sides, the floor space, a section of which is here shown, is 125x144 ft.

On the original installation the type of lighting was the flaming arc for general illumination, and there were also a great number of carbon drop lights at the various benches and machines. These units were replaced by 16-250-watt Mazda lamps giving an average illumination intensity of 3½ ft. candles. Here, again, a few drop lights are in use on some of the drilling machines to satisfy the personal wishes of operators. This building is a three story affair and each of the three floors is equipped throughout in this manner.

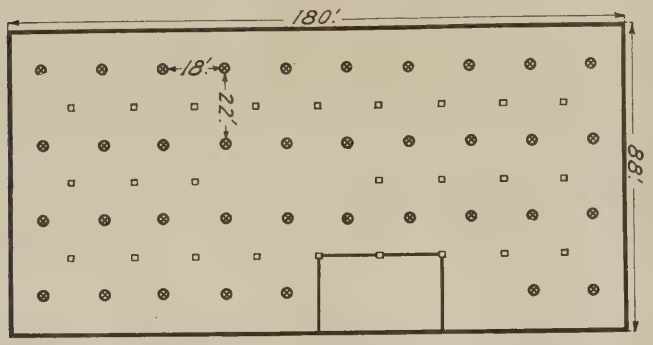


Fig. 2. Plan of Cabinet Shop Showing Location of Fixtures and Posts.

Fig. 3 gives an illustration of the Wood Shop; here, the 250-watt units are used exclusively for lighting. General wood-mill work of all kinds is done here. This shop embraces the second story of one of the older buildings; the dimensions are 200'x100'. It formerly contained 20 enclosed arc lamps with a great number of incandescent drop lamps. The enclosed arc and drop lamps were taken down and supplanted by 40-250-watt units.

Another feature of the illumination at the Pullman Shops, and perhaps one of the most striking, is the illumination in the Power House. Here again, the general practice of using high candle power and high wattage flaming arcs was done away with, and in their place were substituted three 500-watt lamps. The Power House, is 70 ft. x 185 ft., the height of the lamps being 31 ft. The light from these 3-500-watt lamps is the only illumination which is in this building. There are around the side walls of this building, brackets containing 60-watt tungsten lamps, which it was feared might be necessary, but up to the present time there has never been occasion to use these side wall lamps. However, they lend appearance to the Power House, and can be used at any time.

In a brief article such as this it is impossible to cover the field as thoroughly as the subject demands, or to give in detail, the lighting scheme and results in each of the various shops. Such an article would cover a great many more pages than could be given here.

As a specific illustration of the lighting, the new Cabinet Shop has been chosen, since in this room, the lighting is done entirely by means of 250-watt lamps without the use of lights of any other kind. The class work done in this shop requires as good lighting as the average requirements of any shop, so that it offers a fair means of comparison. The work in this shop is of a

Fig. 3. Interior of Wood Shop.

most exacting nature and calls for plenty of well diffused light. Much fine work is done here in matching.

The room is situated on the third floor of a three story brick building, has windows on four sides and is 162x88 ft. The walls are whitewashed but have collected much wood dust, which does not offer the best of reflecting surfaces. The building, being of mill type construction, has supporting pillars at regular intervals, as shown in Fig. 5. In the centre of the room is a skylight 20x40 ft. so that on fairly bright days there is ample light in this room without the use of artificial lighting. Much wood dust is in evidence throughout the room as would be expected here; otherwise conditions are very similar to a great many other shops of this type.

The type of lighting in use here before the installation of 250-watt Mazda lamps consisted of 60-watt Carbon incandescent drop lights entirely; each bench was lighted by 8 of these drop lights, 160 all told. The benches and horses on which work is done are in general, 36" from the floor and are placed on the outside of the room so that the best daylight conditions may be obtained.

Under the old scheme, the lighting was anything but effective there being generally on the benches a series of bright and dark spots and on the whole, the room had a dismal appearance. It seemed as though everywhere one looked there were drop lights. No tests were ever made on the amount of light falling on the work, but from the writer's experience with such lighting, it would seem that there were circles of light varying from two to three foot candles at the lightest point, down to a fraction of a foot candle between lamps.

Under the new conditions, there were installed in this room, 34-250-watt units as shown in Fig. 5. These were installed in the centre of bays, the dimensions of which are 18x22' the units being 10' above the floor or approximately 7' above the working plane.

A general average of 3.5 foot candles is maintained over the working plane in this room. This quantity of light, as has been actually shown under working conditions, was ample for the work being done and has proved highly satisfactory in every respect. In this shop alone the saving in current consumption effected

by the new system of Mazda lighting was 1100 watts. It is impossible, however, to make any comparison of the lighting under the present system as compared with the old. Had it been merely desired to give as much light, it could have been done at a much greater saving, but it must be realized that the object of this installation was to better the lighting conditions primarily, and, if possible, create a saving. That the former has been done in this case is absolutely certain, with a saving of

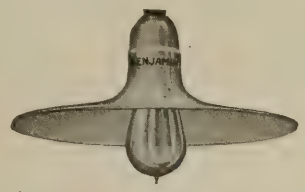
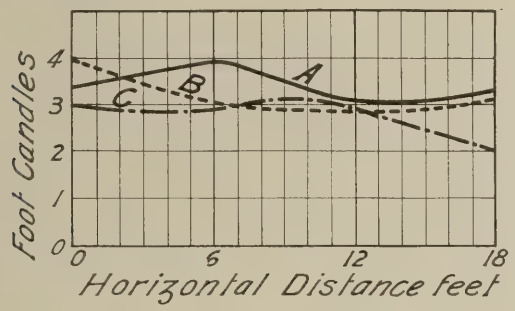


Fig. 4. Flat Cone Reflector Socket.

1100 watts. With the total floor area of this room, 14,256 square feet, a wattage consumption of .6 watts pe rsquare foot is here shown. This is in keeping with the general plan of economy in lighting throughout.

The freight car shop which is the only part of the plant which has series lamps consists of a building 850′ long by 75′ wide and has twelve sets of tracks. In this building 250-watt, 7½ ampere series lamps are scatterred at intervals between tracks, there being altogether 62 of these lamps, all placed on one circuit. The sockets are all equipped with film cutouts thus providing for continuous circuit even though one or more of the lamps burn out. The circuit is controlled by a Westinghouse regulator.



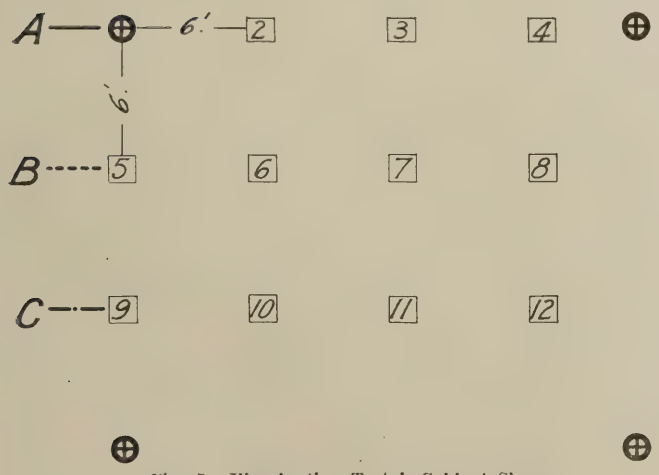


Fig. 5. Illumination Test in Cabinet Shop.

The following gives a detailed list of lamps in different departments and buildings and serves best, probably, to show the variety of work for which this type of lighting is being used successfully. In every case here shown, the unit is a 250-watt Columbia Drawn Wire Mazda Lamp and Benjamin Reflector Socket No. 5501.

The installation of this type of lighting unit means that the first cost of installation is reduced to a cost, the saving on which is only controlled by the type of lamp which has been abandoned. The lamps used have a guaranteed life of 1000 hours, but as a matter of fact the lamps in this installation, after more than eighteen months of continuous service, have shown an average life far above 1000 hours. Here again, some idea of the saving may be imagined.

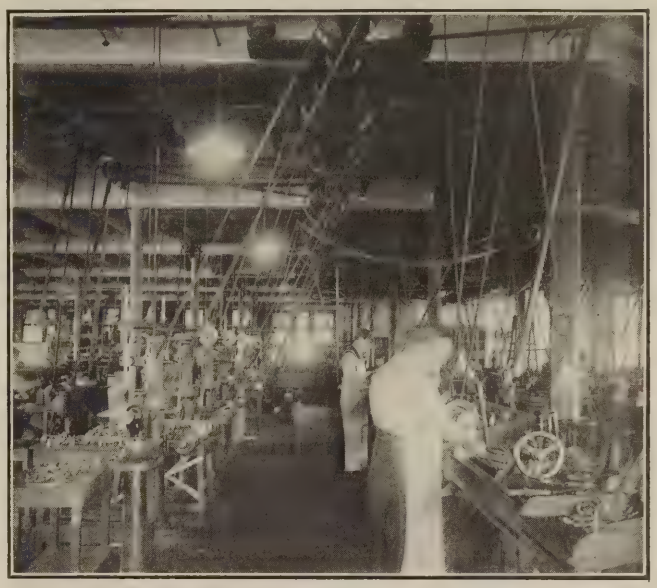


Fig. 6. Interior of Brass Shop.

LIST OF UNITS IN VARIOUS SHOPS.

Upholster Shop	12	Units
Trimmer Supply Room	2	"
Hair Room	7	"
Sewing Room	2	"
Cutting Room	2	"
Shop No. 6	52	"
Shop No. 5	67	"
Store "A"	9	"
Tin Shop	32	"
Car. Electrician Pipe Shop	6	"
Car Inspt. Dept.	6	"
Store E. L.	5	"
Shipping Room	2	"
Store D	3	"
Pipe Shop P. S. and M. Dept.	4	"
P. S. & M. Office	3	"
P. S. & M. Machine Shop	8	"
Steel Cabinet	16	"
Power House	3	"
Old Freight Paint	14	"
Stock Room	13	"
Sealing Room	6	"
Linning Room	10	"
Saw Filing Room	2	"
Old Wood Machine, 3rd Floor	45	"
Iron Machine	12	"
Tool Room	2	"
Glue Room	16	"
Old Cabinet	31	"
Body, Wood Machine Shop	44	"
2nd Floor	50	"
3rd Floor	20	"
Boiler House	10	"
Boiler House Basement	6	"
Enameling Room	6	"
Brass Fnish—1st Floor	28	"
2nd Floor	29	"
3rd Floor	9	"
White Metal Shop	8	"
Glass Plating Room	4	"
Glass Plating Room	4	"
Glass House	16	"
Car Steam Fitters Room	17	"
Pass Steel Shop	10	"
Watt Avenue Gate	2	"

Shop No. 2	60 "
Shop No. 3	48 "
Pass Drill Room	14 "
Pass Truck Shop	4 "
Iron Repair Shop	1 "
Wheel Shed	2 "
Main Office—3rd Floor	6 "
Blue Print Room	2 "
Photo Room	2 "
Main Office—2nd Floor	9 "
Draft Room	6 "
Supt. Office	1 "
Main Office&1st Floor	4 "
Fire Department	5 "
Lobby Main Office	3 "
Store Room "B"	16 "
Old Wood Machine Shop—2nd Floor	68 "
Dry Kilns	6 "
Rolling Mills	25 "
Hammer Shop	12 "
Bolt Room	12 "
Wheel and Axle Department	15 "
Riveting Shed	18 "
Blacksmith Shop	24 "
Out Side Lamps	28 "

COST OF TRAIN LIGHTING.

The *Electrical Review* (London) for May 3rd contains an article by Mr. C. Toone on the cost of railway train lighting in England.

Mr. Toone says that there can be no doubt that electric lighting is the safest possible means of illuminating railway passenger vehicles, and there are now so many excellent systems of energy production, or transport, and of distribution of current from coach to coach, that a suitable arrangement is at hand for every class of railway, and, apart from discussions as to the illuminating "qualities" of the various sources available, the adoption of electric lighting turns mainly upon the question of annual cost. A number of authorities have *estimated* the latter for various lighting systems. Dr. Jakob, of Baden, has collected the latest available data concerning five large Continental railways, using respectively:—A, oil gas and ordinary mantles; B and C, ordinary coal gas and inverted mantles; D, electric lighting from accumulators; E, electric lighting from carriage dynamos. The chief of the result derived are given below, together with simple formulæ for estimating the total annual costs of the various systems considered (see also *Elektrotech. Zeit.,* January 11th, 1912.)

As a basis of estimate and comparison, assume a mixed second and third class eight-wheeled coach, running 62,500 miles per annum at an average speed of 30 M.P.H.; then the running hours per annum average 2,000. to which may be added 20 per cent. to cover stoppages and lighting in stations before and after arrivals. An allowance of 300 C.P. per coach and burning hours equal to half the total running hours is assumed. Gas or accumulator equipment may have 24 hours, and the battery in a dynamo e dynamo equipment 10 hours' capacity.

Including capital, maintenance and energy charges (and all wages reasonably chargeable to this account), the lighting and total costs per annum, in the cases referred to above are given in francs as follows:

Case.	A.	B.	C.	D.	E.
Actual lighting	182.0	103.1	86.6	177.5	59.4
Total annual cost "K" of lighting equipment	492.3	493.0	526.6	652.8	376.5

From these figures it will be seen that the total costs of the above lighting equipments average 500 fr. for the gas systems, 650 fr. for electric lighting from accumulators, and 375 fr. for electric lighting from train dynamos. Depreciation and maintenance constitute the chief items of expense in the accumulator system; depreciation costs are rather higher in the dynamo than in the gas equipments, but the former effects very important economies in maintenance and the actual cost of current production.

A general formula for the total annual cost (K frs.) of a lighting system is—

$$K = c^1 + c^2 W + c^3 B,$$

in which, W = the annual track miles traversed, expressed in 100,000's of kilometres; B = lighting period, expressed in 1,000's of hours; $c^1 c^2 c^3$ = constants depending on the lighting system employed.

For gas lighting :—$K = 150 + VBE\ W + 194\ B$, and $h = 0.065 + 50/1{,}000 \cdot B + 41.25\ W/1{,}000 \cdot B$ (h = centimes/C.P.-hour).

For accumulator lighting :—$K = 171.25 + 155 \cdot W + 272.5 \cdot B$, and $h = 0.0912 + 57.5/1{,}000 \cdot B + 51.25 \cdot W/1{,}000 \cdot B$.

For dynamo lighting :—$K = 152.5 + 158.75 \cdot W + 55.75 \cdot B$, and $h = 0.0175 + 51.25/1{,}000 \cdot B + 52.5\ W/1{,}000 \cdot B$.

The fixed charges and those dependent on the distance traveled, are much the same in each case, but the 1,000-hour value of those depending on the lighting hours are about 200 fr. for gas lighting, and 272 and 54 fr. for electric lighting by accumulators and dynamos respectively. Lighting by accumulators alone, is always very costly.

If the fixed costs be equal, the cost of lighting by gas and by dynamo is the same when B/W =1-4, *i.e.*, when one hour's lighting is required for every 400 kms. train miles (about 8 hours' run). For longing lighting periods per train mile, the dynamo system is the cheaper.

On very long journeys, such as are common on Continental and American railways, it may be necessary to carry a double supply of gas or two sets of accumulators. Such a necessity at once enhances the relative superiority of the dynamo system and the new equations for K become :—

Gas ..... $K = 150 + 169 \cdot W + 194 \cdot B$
Accumulators .... $K = 275 + 244 \cdot W + 275 \cdot B$
Dynamo ..... $K = 150 + 150 \cdot W + 56 \cdot B$

and dynamo lighting shows considerable economy even for small values of B (the lighting hours). The general conclusion to be derived from the above notes is that dynamo lighting is always preferable to accumulator lighting for trains, and that the former will usually show a greater or less economy over ordinary incandescent gas lighting.

BALL BEARINGS.

The appointment of a special committee on ball bearings made at our annual convention in November, marks the awakening of interest in this subject which now seems to have gained a great impetus and will doubtless result in the general adoption of ball bearings for axle generators.

It is claimed by one manufacturer that ball bearings save 90 per cent in the cost of lubricants and 90 per cent in labor or lubrication.

It is certain that ball bearings require very much less attention than do bearings of the ordinary type, and with the development in ball bearings in the past few years, induced largely by the automobile idustry, these bearings are now entirely reliable and give long life even in the most severe service. As a matter of fact, there are a large number of trolley cars, weighing even as high as 40 tons, mounted entirely on ball bearings. The severe service of blows and vibration of a trolley car at high speed offers a pretty good test as to the reliability of these bearings when operated in railway car lighting service.

Planning and Equipping of Railroad Shops

GEO. W. CRAVENS

The magnitude of this subject is so great that it is manifestly impossible to do more than touch upon the more important portions in an article of this sort. Each phase of it is worthy of an entire volume, and many such have been written, but conditions are changing so continually that elaborate compilations are liable to be out of date before leaving the printer's hands. Therefore, we shall deal more specifically with those phases which have to do with the planning and electrical equipment of railway shops.

It will be evident to even the most superficial observer that no two shops can be exactly alike and be equally efficient, nor can any set of definite rules be laid down which can be followed implicitly when laying out a new shop. On the other hand, experience shows that there are certain more or less general laws which may be used as a guide in studying the existing conditions and which will help in formulating a mode of procedure for the preliminary layout.

Unquestionably, the first and best thing to do is to make a careful, comprehensive and detailed study of existing shops, old and new, especially those operating under conditions similar to the assumed conditions of the proposed new one. This survey should take into account not only the arrangement and equipment of the buildings but also the operating conditions of the road, the organization and management of the shops, the amount and nature of the rolling stock, the policy of the road, the men behind the organization, the probable future conditions as presaged by present tendencies, etc. And this is no child's job.

Among the more important preliminary data required, the use and value of each being evident to experienced railway officials, may be mentioned the following:

1. Character of Traffic.
   (Suburban or through, freight or passenger, light or heavy.)
2. Grades and Curvature of Tracks.
   (Many or few, character, effect on rolling stock, etc.)
3. Water Supply.
   (Quantity, quality, location, cost, etc.)
4. Types of Locomotives.
   (Sizes, design, service, speed, distribution, etc.)
5. Number of Locomotives and Cars.
   (Total, distribution, per division, service, etc.)
6. Relation of Shops to Sources of Supply.
   (Labor, material, water, fuel, etc.)
7. Cost of Land, Buildings and Labor.
   (First cost, taxes, insurance, interest, upkeep, etc.)
8. Size, Shape and Location of Land.
   (Compact or scattered, along tracks or distant, etc.)
9. Kind and Amount of Work to be Done.
   (Building, repairing, cars, locomotives, both.)
10. Policy of Management as to Expense.
    (Low first cost or economical operation, room for growth.)
11. Probable Changes and Extensions.
    (Shifting departments, increasing business, consolidations.)
12. Power, and Method of its Use.
    (Mechanical or electrical transmission, drives, etc.)
13. Division Repair Shops and Equipment.
    (Effect on main shop, Light or heavy repairs, etc.)
14. Relation to Associated Lines of General System.
    (Financial, physicial and political, interchange, etc.)

Numerous other controlling factors might be mentioned in a complete exposition of this subject, but these will suffice to give an idea of the general problem and its principal factors. Every railroad has its own peculiar conditions to meet and its shops must be planned in the light of the fullest information available. The success or failure of the new shop will depend upon how carefully the problem has been worked out.

In all cases the layout finally adopted is more likely to be the most practicable under the existing conditions than the ideal or theoretically perfect one for the work to be done. Each and every one of the factors listed above, and more, will have a definite effect upon the problem, the answer depending upon their relative values. Probably the most important single factor, in recent years at least, is the very general adoption of electricity as the distributing medium for the power. This not only allows a central generating plant but makes possible the arrangement and re-arrangement of the machine tool equipment to suit varying conditions without appreciable expense, low operating expenses and increased outputs, reduced investment in building, line shafting and belts, better speed control, etc.

Probably the factor of next importance in its influence on the general layout is the electric travelling crane. Originally the transfer table was the limiting factor because all buildings doing work on assembled locomotives or cars had to be tributary to it. Now the large cranes can pick up a heavy locomotive or car and shift it from one end of a shop to the other and from track to track about as quickly as it would take to get the transfer table in place and the load on it.

Then comes the enormous improvements in shop appliances and the adoption of high speed tool steels as factors in the problem. In practically every shop in the world today may be found the good effects of these factors. Many old shops have been remodelled or rebuilt since the advent of modern methods and equipment, and others have adopted them in their extensions. And all new shops are being planned and equipped with a view to taking every possible advantage of scientific methods of management as well as the latest equipment. We will not go into a description of management or methods herein, but they must be taken into account in the layout, for the routing and speed of the work through the shops determines their relation and size as well as their equipment. This is very important.

Another important factor, and one which effects the size as well as the location of the main shops, is the comparatively recent tendency to establish small but well equipped shops at large centers and division points in connection with the round-houses. In some cases these can take care of fairly heavy repairs in case of emergency, but in most cases they are planned for running repairs only. Evidently, this will relieve the main shops to an appreciable extent and keep the rolling stock, especially engines, in operation during a larger percentage of the time. The influence of this tendency on the main shops will be evident. The most desirable location for the main shops is near the center of business of the system, not the geographical center, but physical conditions sometimes modify this.

Therefore, we find that each railroad presents its own peculiar problem and the only possible way to correctly solve it is through long and careful study of as many of the factors as can be discovered. And the best way to discover what these factors are is to see what points have been taken into account by others in planning, locating, building and equipping theirs. So, let us see what some of the leading American railroads have done.

GENERAL LAYOUT.

Assuming that the officials of your road have done their part of work by determining such factors as the location of the shops, stated a policy as to expense, consolidations with other shops and provisions for the future, establishment of division repair shops, relations with associated lines, etc., and that you have investigated the other factors mentioned above (together with as many more as you can think of) the next factor ahead of you is the layout.

It is obvious that those buildings whose functions are to supply or assist all or most of the others should be as near the center of the group as possible. This applies to the power plant, general storehouse and, in most cases, to the blacksmith shop. Next in importance comes the main highway or means of intercommunication between the different parts of the plant, and finally the grouping of the buildings. The last mentioned is not the least important, nor should it be entirely ignored until the other points are settled. The only excuse for the existance of a shop at all is to have it perform certain functions as quickly and cheaply as possible, in order that the equipment may be in money earning service as much of the time as possible. And the arrangement of the buildings is vital to this.

A study of existing shops, such as has been done in writing the series of shop descriptions now running in the *Railway Electrical Engineer*, shows almost as many kinds of layouts as there are roads. This is *not* due entirely to the honest differences of opinion among the members of the mechanical departments, as some seem to think, but in a larger measure to the fundamental differences in local conditions, as stated above.

Taking the matter of locating the "general utility" buildings first, we find that most of the shops which are more than twenty years old have either no central power plant or have one at one side or end of the group of buildings. In most cases such plants have two or more boiler houses scattered around the yards supplying steam to the separate buildings for driving steam engines. Some of these old shops have recently had central power plants built in or near the load center of the shops. Storehouses, however, are in nearly all cases near the locomotive shops and accessible to the car shops, and blacksmith shops are also close to locomotive shops.

As to the main highway or means of transportation between buildings there is less agreement manifest. This is due to the influence of the transfer table and electric crane on the layout. In the earlier days the crane had not been developed to the point of usefulness as at present and the transfer table was the only means available for moving cars, trucks and engines at right angles to the interdepartmental trackage system. And we all know what a nuisance it is to have to be continually crossing the transfer pits with wagons or small hand trucks loaded with heavy materials.

The advent of the traveling crane (overhead) and the yard gantry crane, first operated by hand or compressed air and later by electricity, has had a marked influence on the layout of modern shops. This is due to the use of the cranes as one of the principal means of transporting materials between buildings, as well as within them. So the trend of design of layout has been from that depending entirely upon the transfer tables to the layout with no transfer tables. As to whether the transfer table may be permanently dispensed with in all cases, or even in any case, time alone will tell. The chances are that it will always be used to some extent, even as horses will not be entirely superseded by automobiles.

Some time ago Mr. Walter G. Berg, Chief Engineer for the Lehigh Valley Railroad, made a careful and quite complete study of the leading American railroad shops and classified them according to their layouts as follows"—

A—Complete Transfer Table Layout.
- (a)—All departments combined along one transfer table.
- (b)—The various departments grouped along separate tables.

B—Combination of Transfer Table and Longitudinal Layout.
- (a)—Longitudinal freight car shop; all other departments with transfer tables between.
- (b)—Longitudinal locomotive erecting shop, longitudinal freight car shop, transfer table for passenger car shop.

C—Combination of Transfer Table and Cross Locomotive tive Shop with Crane.
- (a)—Cross locomotive erective shop with crane for lifting engines, with transfer tables for all other depts.
- (b)—Cross locomotive erecting shop with crane for lifting engines, passenger car shops with transfer table, and longitudinal freight car shops.

D—Layouts without Transfer Tables.
- (a)—All longitudinal layout.
- (b)—Cross locomotive shop with crane, otherwise longitudinal.

A study of recent shop layouts shows a growing tendency to concentrate the building along a craneway (the means of intercommunication between departments) similar to the older method of keeping the buildings along the transfer table, and arranging the shops of each group according to their respective functions. The Big Four Shops at Beech Grove (Indianapolis) described elsewhere in this issue, the Grand Trunk Shops at Battle Creek, the Lake Shore Shops at Collinwood and the Frisco Shops at Springfield (Mo.) are all provided with crane ways as above outlined.

The author, therefore, suggests the addition of another classification to those suggested by Mr. Berg, as follows:

E—Combination of Main Craneway with Transfer Table.
- (a)—All departments tributary to crane served midway. (Big 4.-
- (b)—Locomotive departments tributary to craneway with transfer served car departments isolated. (Frisco or L. S. & M. S.)

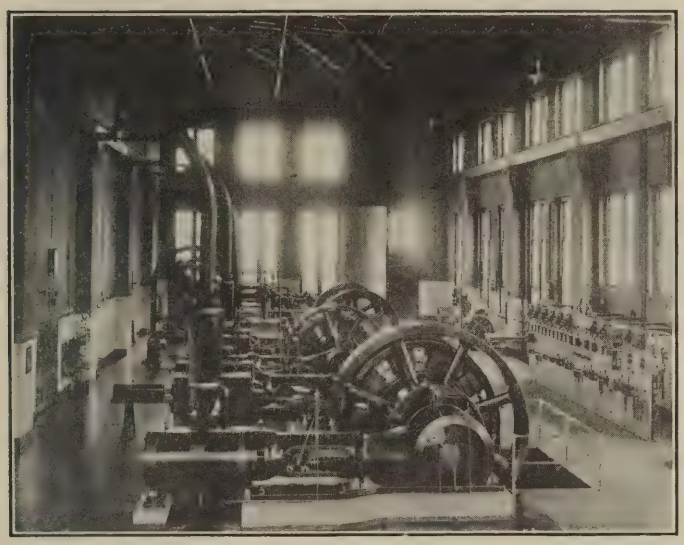
Of the two references cited under subdivision "b" the layout at Collinwood (L. S. & M. S.) is best suited for the average road, that at Springfield (Frisco) being planned for enormous and unusual expansion, but worthy of study, nevertheless.

The Chicago-Great Western shops at Oelwein, Burlington at Hannibal, Colorado & Southern at Denver, M. K. & T. at Sedalia and L. & N. at South Louisville have transfer tables as the main source of intercommunication.

Along with yard cranes and transfer tables must be considered the track arrangements, both inside and outside the building. Here is where the wide differences due to transfer tables and cranes is most evident. With the former there must be a door in the side of the buildings for each track while with cranes a door at each of the end tracks or one in the middle of the building is enough. The big cranes will lift a locomotive over the others and put it wherever required. This applies to the

locomotive shop principally, for the car departments are still best served by transfers between the several buildings unless the climate is very severe.

The storehouse should have tracks on both sides with platforms at the car floor level. Small cranes are also provided to help handle heavy materials, many store-



Typical Power Plant with Reciprocating Engines.

houses having telpher systems so arranged as to carry the materials directly to the bins from the cars. At least one track should enter the blacksmith shop and foundry and convenient connection should also be made with the scrap yard and iron storage spaces or buildings. The lumber yard and planing mill should be near together and connected by tracks with car shops.

A very important factor in determining the class of layout, and one which is sometimes unavoidable, is the necessity for ranging the shops along the right of way of the road. It is obvious that the size, shape and topography of the land will frequently be of such a nature as to compel a layout which is not economical or even convenient. This is especially true where the strip is very narrow in proportion to its length, although some engineers have succeeded quite well in spite of such a handicap. Adequate provision for extensions must also be made, and the failure to look ahead far enough often leads to great future losses and inconvenience. The recently completed shops of the St. Louis & San Francisco Ry. at Springfield, Mo., offer one of the best examples of foresight in this country. Provision has been made here to double the present shops and then, later, to double them again with economical operation at all times.

The locomotive shop is the most important of any plant, so its location and arrangement must be given first consideration. Those who advocate the longitudinal arrangements are about equal in numbers to those who prefer the transverse. Both plans have their good features but the transverse seems to be the best for most conditions, and especially where there is no transfer table.

The locomotive shops of the Buffalo, Rochester and Pittsburg Ry. at Du Bois, Pa., offer a good example of a longitudinal locomotive shop with three lengthwise tracks and a transfer table at one end running at right angles, and parallel with the boiler shop. The locomotive shops of the Pittsburg and Lake Erie R. R. at McKees Rocks, Pa., are an equally good example of the transverse locomotive shop with a number of stalls at right angles to the center line of the building, access being had by three or four tracks at intervals along the building with cranes to shift the engines from track to track.

ELECTRICAL EQUIPMENT.

Before the power plant can be laid out or its apparatus determined upon, the equipment of the shops must first be settled. But we will consider the power plant first in this article because that is the arrangement followed in the articles written for this paper by the author, and our readers are accustomed to it.

The best location for the power plant is unquestionably as near the load center of the plant as possible. This means present and ultimate load as far as they may be determined. This is especially true of plants using continuous current on account of transmission losses, due to lower voltages than with alternating current (usually). There are some exceptions to this, of course, but this is the rule. Adequate and easy provision for coal supply and the removal of ashes must be made, and these sometimes influence the location of the power house as well as its design.

Preferably, the coal should be dropped down through the car floor to a track hopper between the rails, thence to a conveyor and up to bunkers overhead in the boiler room for feeding down through spouts to the stokers (if stokers are used, as they should be). From the grates,

Typical Power Plant with Steam Turbines.

ashes should drop into hopper which can be emptied into the conveyor again and carried to an ash hopper overhead ready to be run through a chute to empty cars outside for removal. An equipment like this will soon re pay its cost in operation expenses saved. As to the type of boiler to use there is very little choice between the various watertube boilers now on the market, the firetube boiler being practically superseded now for power plants of any size.

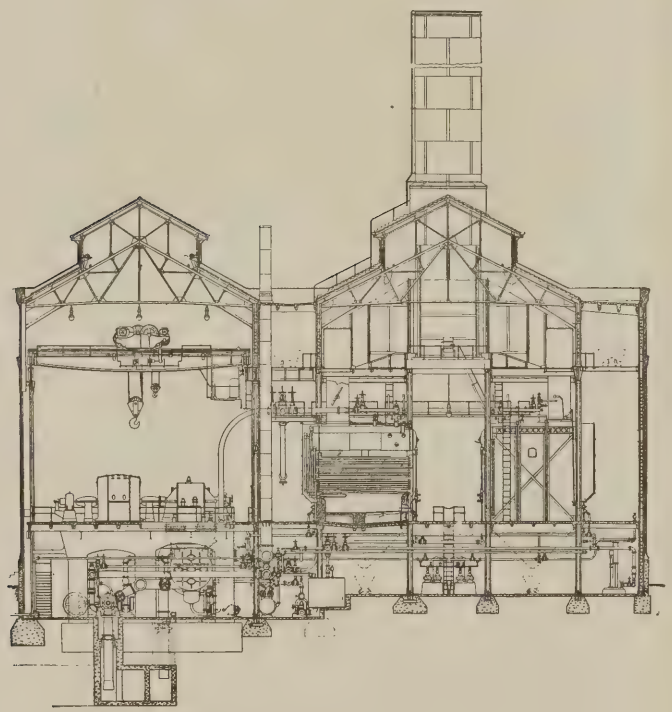
The battle between the steam turbine and the reciprocating engine still goes merrily on, with a recent tendency toward horizontal turbines instead of the vertical type. One great advantage from the adoption of turbines is the reduced cost of generators due to the high speeds of rotation. This results in a smaller generator for a given capacity, with consequent lower cost.

On the other hand, the use of steam turbines for railway shops (or any others requiring steam for heating), on account of their large size and amount of glass radiating surface, makes the expense of steam supply a very material consideration. Where noncondensing recipracating engines are used, or even condensing engines with suitable auxiliaries, together with a good exhaust steam

heating system the cost of heating becomes a comparatively small factor of expense.

Recent improvements in alternating current motors for driving shop tools have brought them to practically the same degree of flexibility as to speeds as the direct current motor, so the only factors now to be considered are those of voltage drop in transmission and the power factor of the system as a unit. Hence, a power plant may be arranged in approximately the same way for either method of distribution.

The switchboard is a much more important part of the power plant equipment than some engineers seem to believe, judging from some of those now in use. Not only should it contain panels enough for all of the generators, motors and feeder circuits, but each panel should have a complete equipment of meters, switches, etc., to allow the fullest knowledge and control of conditions in each circuit. A few dollars more spent on the switchboard will frequently result in incalculable benefits in operation of the plant. The board in the new power plant at the Pullman Co. shops is considered one of the finest examples of this in the United States.

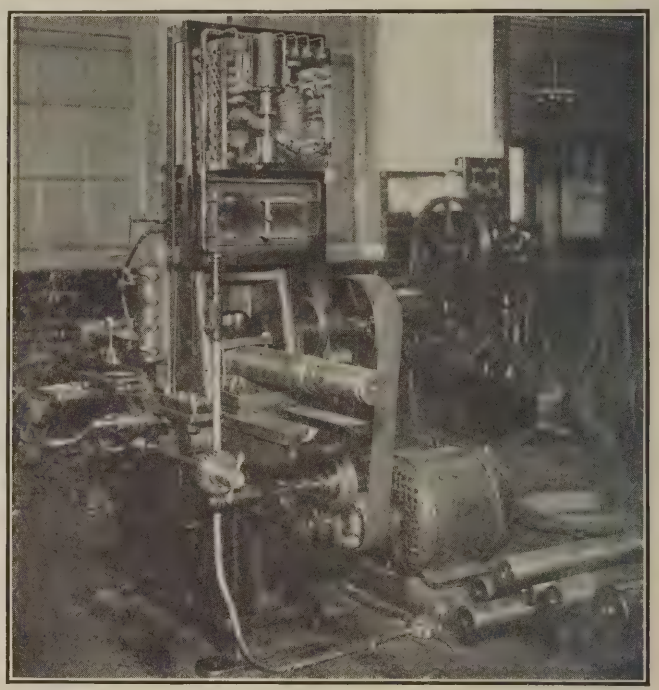


Cross Section, Typical Large Railway Power House.

The distribution of power to the various shops from the power plant may be done through overhead or underground cables, the present tendency being to construct tunnels throughout the yards and to have all steam, water and air pipes as well as electric cables in them. This makes frequent inspection easy and results in fewer cases of trouble due to breakdowns. Overhead lines are carried along the buildings in many of the older plants and on wood poles in others, with steel poles now being used in some of the newer ones. At the West Albany shops of the New York Central Lines all wiring is on steel towers, separate cables and wires being run from the feeder panels to each point of application of the power. This is an extreme case, the rule being to run a heavy feeder to a distribution center in each building and dividing there into several local circuits. At some shops using alternating current, transformers are located outside of each shop to reduce the transmission voltage to that of the motors and lights inside and then carried in to a distribution panel.

ELECTRIC MOTORS.

Turning now to the question of what kinds of motors to use for the various classes of apparatus, let us first consider the peculiarities of each type. There is no room for argument as to the use of anything but electric motors where they are at all applicable, and that means practically any place where power is used to produce motion. Among the benefits derived from their use in driving machine tools may be mentioned decreased transmission shaft losses, increased production through easy speed control, accurate knowledge of power required for a given purpose, ease of power control and distribution, flexibility of machine arrangement, reduced vibration of buildings and machines and the elimination of most of the belt troubles.



Typical Motor Driven Milling Machine.

Direct-current or continuous-current motors are usually designed for use on constant potential circuits, three kinds being available for driving machine tools: series-wound, shunt-wound and compound-wound. Each of these has its field of usefulness, as well as its limitations, and will be described in detail as we go along. Direct-current motors for use on multiple-voltage systems are also made but are not in very general use on account of the comparatively complicated controllers required. It is also necessary to use a motor large enough to deliver full load at the lowest voltage, which makes this system more expensive to install.

Alternating current motors are also usually designed for use on constant voltage systems and are of two kinds, synchronous and asynchronous. That is, they are designed to run at a fixed speed in the first case or at varying speeds in the second case, the latter finding the widest application in machine shops. Motors of this kind may be obtained for operation on single-phase, twophase or three-phase circuits, the single-phase and three-phase being the most used. For variable speed work the three-phase motor is better, the asynchronous or induction motor finding the widest application. However, these mo-

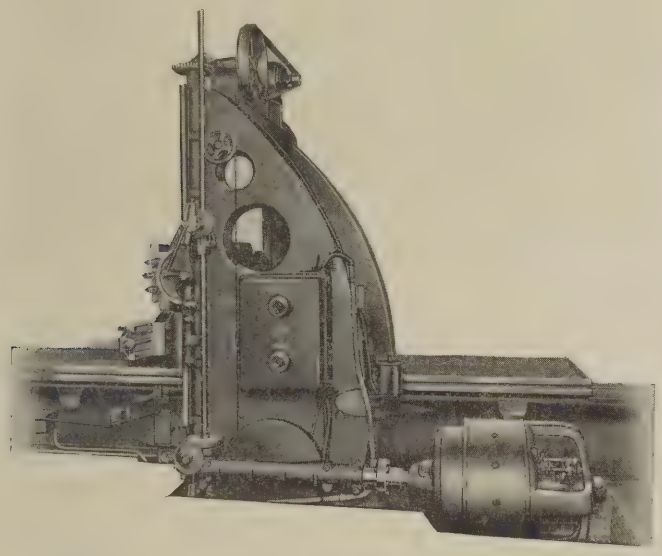
tors have their good and bad points and will also be considered in detail as we progress.

Without going too much into the details of design and construction of the various kinds of motors, let us consider the operation of the different types. Then we can determine what sort of motor to use under a given set of conditions.

When a motor is running the quantity of current passing through its armature is limited by two things, the resistance of its windings (which is constant) and the "counter electro-motive force," (tending to choke back the current through setting up a "counter" voltage in the conductors), this counter e. m. f. being proportional to the product of the field strength and the armature speed. When multiplied by the current flowing, the counter e. m. f. represents most of the active energy in the motor.

A series motor is one in which the current is caused to flow first through the armature windings and then through the field windings before passing back to the line, hence the field strength will vary with the amount of current passing through the armature and the speed will vary to correspond, but inversely as the field strength.

Hence, if we have a series motor running under a certain load the speed and torque or pull will be steady.

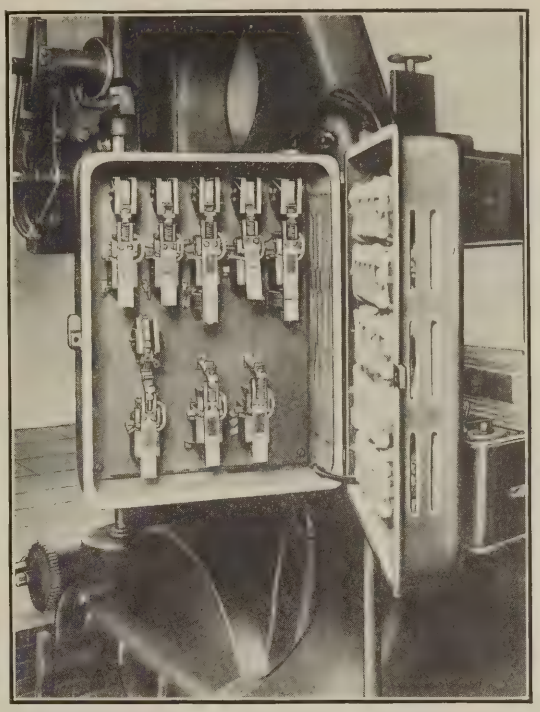


Recently Developed Reversing Motor Drive for Planers.

If we reduce the load the speed will immediately increase because less torque is required. But, the increased speed will increase the counter electromotive force which will in turn reduce the amount of current flowing. This will weaken the field and compel the motor to run faster in order to generate the same counter e. m. f. as before, so the motor races or "runs away." That is why series-wound motors are not so well adapted to driving machine tools as the others. They are good, however, for cranes, hoists, locomotives and other places where they are under the control of an operator at all times.

Shunt-wound motors are so built that the field windings are connected directly across the line, thus providing for constant field excitation and strength at constant voltage. The armature is in series with the line and the current varies with the load. The armature resistance is very low, and causes but small drop in the voltage through resistance, hence the counter electro-motive force must be almost as high as the impressed e. m. f. or line voltage at all times, and the speed will therefore be practically constant. The speed of a shunt motor can be varied through a wide range very easily, although the torque depends solely upon the amount of current passing through the armature windings.

Compound-wound motors are a combination of the two types just described, having both series and shunt connected windings in their field coils. They start with



Automatic Control Panel for Planer Reversing Motor.

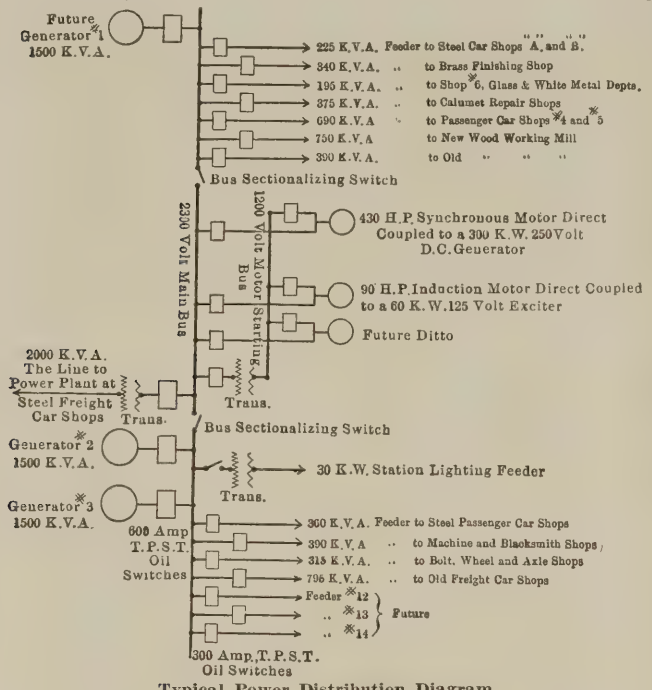
comparatively high torque, like series motors, because of the series winding, but the high speed is limited by the shunt winding so they will not run away under no load. The speed may be adjusted at any desired point with a given load, but it will vary slightly with the load due to the series winding.

The speed of a motor may be varied in different ways, all of which are based upon changing the effective voltage applied. By placing a variable resistance in series with the armature the speed may be varied from full speed to zero, but this is wasteful of energy and reduces the torque of the motor. With shunt and compound-wound motors, the better and customary way is to connect a rheostat in series with the shunt field winding. With properly designed motors this method allows variations of four to one in speed; that is, a reduction to 25% of full speed at constant torque.

It will be evident from the foregoing what kind of motor to use for the various classes of service. For instance, suppose you had a planer to equip and attached a series motor to it. What would happen if you tried to plane off the bosses of a large base casting? When cutting metal your motor would slow down, due to the load, but when passing free from one boss to the next your motor would speed up, and when the cutting tool struck the next boss something would break. Experience shows compound motors to be better suited to this service, and so on down the list.

Series-wound motors, as previously stated, are best adapted for use where the operator has the motor always under his control, as for hoists, cranes, elevators, locomotives and other classes of intermittent service. The speed of a series motor can be varied only by dissipating energy in the form of heat through a resistance in series therewith, thus reducing the impressed voltage and, in turn, the amount of current reaching the motor.

Shunt-wound motors, because of their speed characteristics and ease of control, are particularly well adapted to driving machine tools. On the other hand, experience shows them to be best fitted to drive tools which do their work with a rotary motion of either the work or the cutting tool. This includes drills, lathes, boring


Future Generator #1 1500 K.V.A.
225 K.V.A. Feeder to Steel Car Shops "A" and "B"
840 K.V.A. " to Brass Finishing Shop
195 K.V.A. " to Shop #6, Glass & White Metal Depts.
375 K.V.A. " to Calumet Repair Shops
690 K.V.A " to Passenger Car Shops #4 and #5
750 K.V.A to New Wood Working Mill
300 K.V.A. to Old " " "
Bus Sectionalizing Switch
2300 Volt Main Bus
1200 Volt Motor Starting Bus
430 H.P. Synchronous Motor Direct Coupled to a 300 K.W. 250 Volt D.C. Generator
90 H.P. Induction Motor Direct Coupled to a 60 K.W. 125 Volt Exciter
Future Ditto
2000 K.V.A. The Line to Power Plant at Steel Freight Car Shops
Trans.
Trans.
Bus Sectionalizing Switch
Generator #2 1500 K.V.A.
30 K.W. Station Lighting Feeder
Trans.
Generator #3 1500 K.V.A.
600 Amp T.P.S.T. Oil Switches
360 K.V.A. Feeder to Steel Passenger Car Shops
390 K.V.A " to Machine and Blacksmith Shops
315 K.V.A. " to Bolt, Wheel and Axle Shops
795 K.V.A. " to Old Freight Car Shops
Feeder #12
" #13
" #14
Future
300 Amp. T.P.S.T. Oil Switches

Typical Power Distribution Diagram.

mills, milling machines, etc., rather than machines with a reciprocating motion like planers, etc. For the service stated there is nothing better than a shunt-wound, variable speed motor with good inherent speed regulation.

Compound-wound motors are best suited for driving planers, slotters, shapers, rolling-mills, punch-presses and other machines with a reciprocating motion of either the tool or the work. This is due to the fact that the greatest demand for power is at the instant of reversal of motion, and the series winding causes an increase of torque as the speed drops due to the increased load at this instant.

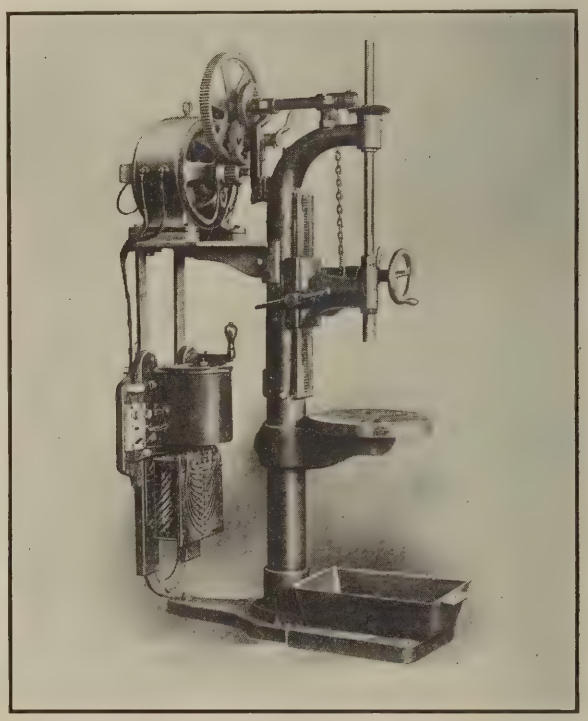
The load curve of a compound motor may be greatly smoothed out by adding a fly-wheel, and it will tend to save the motor. For machines of the class stated, motors of larger capacity are required than for machines operating with a rotary motion and removing the same amount of metal, so fly-wheels will tend to reduce the size motor required for a given machine.

Alternating current motors are also built in a variety of forms and some of them possess certain advantages over direct current motors for special classes of service. Synchronous motors operate at constant speed regardless of load, up to the stalling point, so long as the speed of the generator driving them remains constant. But they require the separate excitation of their field windings with direct current, the same as an alternating current generator, so are seldom used in machine shops except in the larger sizes. They may be used, however, where constant loads are to be carried at constant speeds, such as for blowers and pumps operating continuously, and for driving generators which operate at constant potential. There should always be one in plants using induction motors for power in order to bring up the power factor.

Induction or asynchronous motors are of two general types, those with "squirrel cage" or short circuited armature windings and those with armature resistance external thereto for speed regulation. The latter class is further subdivided into two styles, those with the resistance elements mounted inside the rotor, or armature, and those with contacts, or "slip rings," on the armature and leads running to resistances mounted elsewhere. Small sized induction motors are nearly always of the squirrel cage type with the primary windings only connected to a circuit. The only way to change the speed of such motors is through voltage variation through transformers or resistances, and this effects the torque of the motor.

The no-load speed of an induction motor is practically synchronous with that of its source of supply and its full load speed from 3 to 15% less, depending upon its size. In order to develop torque an induction motor armature must "slip" or fall behind the synchronous speed, and the amount of this slip varies directly with the load and the resistance of the armature, and inversely as the square of the voltage applied.

The running torque is directly dependent upon the resistance of the armature, the slip and the square of the voltage, while the maximum torque is independent of the rotor resistance. Induction motors with external resistance as described will operate at full-load torque with the speed reduced as much as 50% without overheating.



Typical Individual Drive for Drill Presses.

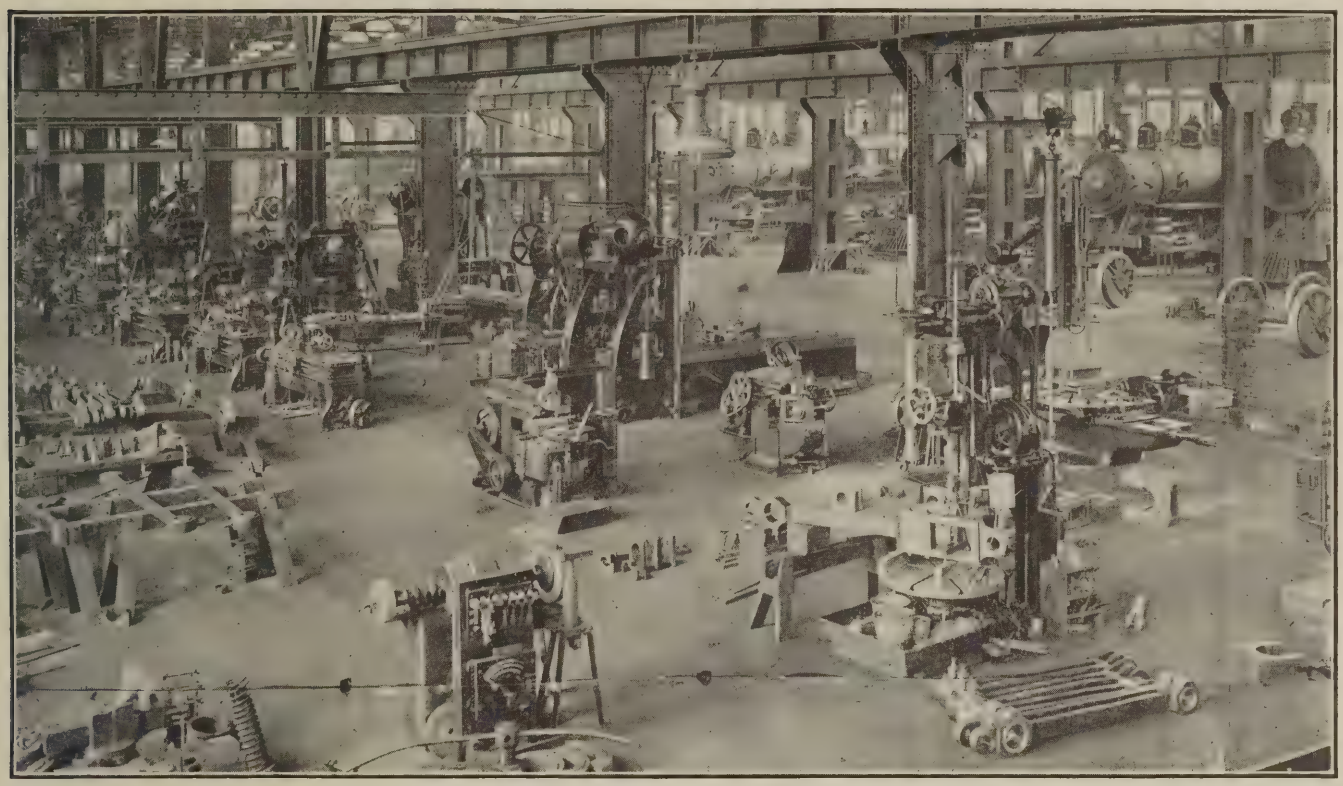
Induction motors with squirrel cage rotors are suitable for use where speed variation is unnecessary during a given operation, such as for pumps, fans, drills, grinders and other places where motors with the characteristics of shunt-wound direct current motors are required. Speed variation, however, can only be obtained through varying the voltage or with speed changing gears on the machine, both of which are undesirable. Squirrel cage motors are good for use in oil houses, woodworking shops and other places where inflammable materials are found as there is no moving contact and no sparking.

Induction motors with variable secondary resistance, on the other hand, may be run at speeds of anywhere between half speed and full speed, at full load, and are suited to most any class of service that either shunt or

compound direct current motors are. Recently a new form of induction motor has been brought out for use on planers and other machines requiring a reversible motor. This motor is so designed that it will stop from full speed, reverse, and come up to full speed again in the time ordinarily taken to shift the belt on a planer, and its switch is operated by the dogs on the planer bed.

heating, ventilation and sanitation, and the facilities for handling materials. Large skylights run along the center of the roof over the main bay with saw tooth roofs over the galleries at the sides, and in one recent shop there is one square foot of window for every three feet of floor area.

Differences of opinion exist as to the relation of the



Typical Motor Driven Railroad Shop. No Belts Overhead.

Reliable data as to the power required to drive the different classes of machines is very hard to obtain from outside your own shop, so the best thing to do is to get a large motor and attach it to the machine in question and test it. Several reliable makes of graphic meters are now on the market and a great amount of benefit is resulting from their use. Tests conducted under various conditions of operation have been made by several of the railroad companies in their shops and very valuable data has been compiled. In many cases the size of motor recommended by the machine tool maker has been found much larger than necessary and money has been saved as the result of making the tests.

LOCOMOTIVE SHOPS.

The locomotive erecting and machine shop is usually the main one of any railway shop, so its size, location and equipment must be given very careful study. For our purpose here we will be content wtih a survey of the field and see what has been and is being done by American railway companies.

In the older shops very little attention seems to have been paid to the design of the building, most any old thing with a roof being used. Later shops are of brick with an apparent attempt to provide adequate light and ventilation but are poorly arranged for the prompt and economical pushing of work. Modern shops are given as much study as shops for large industrial establishments, and the details of choosing and placing tools, erecting pits, cranes and other features are considered settled only when as nearly perfect as they can be made.

Modern buildings are usually of steel frame construction with brick or concrete walls, but as much window space in the sides and roofs as possible. Especial attention is paid to stability, natural and artificial lighting,

machine shop to the erecting floor, some preferring them parallel and others at right angles, some with the machine bay entirely in one section and at one side, others with two erecting bays and one machine bay between, and others preferring two machine bays with one erecting bay between. The majority, however, advocate and use a single erecting bay with a single machine bay parallel thereto, a number of them having a gallery containing light machines also. In several instances the boiler and tank shops are also under the same roof, sometimes in a bay and frequently at one end in order to use the main cranes. This makes a good arrangement and adds to the convenience of moving the boilers, plates, tubes and other materials, especially when making repairs requiring the complete dis-assembling and re-erection of the locomotive.

The relative proportions of the various departments is another important consideration. Usually, the floor area bears a definite relation to the number of erecting stalls, but changes in the size and types of engines, higher steam pressures, differences in materials and changes in traffic handled all contribute to upset calculations sometimes. Broadly speaking, the areas of the erecting floor and boiler departments should be about the same, with the machine tool section about 50% greater than the erecting floor area if new engines are to be built in addition to extensive repairs. However, the output of the departments is the real factor to consider rather than the mere areas occupied, and this in turn will depend to a large degree upon the management of the departments and their equipment.

There seems to be no great advantage in one arrangement of erecting pits over any other, there being three now in use. These are the transverse, longitudi-

nal and diagonal, the transverse being necessary with transfer table service. But the use of heavy cranes now makes the moving of engines so easy that most recent shops have transverse pits with but two or three tracks extending outside of the building. A single large crane will serve such shops while the diagonal or "herring bone" arrangement demands two cranes to lift an engine, but of smaller capacity each.

Provisions for the distribution of material must be such that it may be rapid, easy, economical and continuous, and preferably in a "straight line" movement. That is, the progress of work through the shops should be always forward instead of back and forth in order to facilitate handling. This can be accomplished by the provision of plenty of trucks, tracks, transfers and cranes, backed up by good management. And it might be added that a surplus of machines and tools is better than a shortage when it comes to keeping the rolling stock in service.

At the present there is a tendency towards increasing the number of machine tools per pit. The average is between 6 and 8 per pit with many shops having from 5 to 6, but the tendency is towards from 8 to 10 per pit in several recent shops. When the full effect of scien tific methods of management have been realized it may be possible to return to the old proportion of 5 or 6, and still turn out more work in a given time. As to how many tools of each kind will be required there is no fixed rule, but a survey of the field shows the following proportions in existing shops:

PERCENTAGE OF TOOLS OF EACH TYPE PER ERECTING PIT.

Turning Tools	50%
Cutting Tools	25%
Drilling Tools	11%
Grinding Tools	7%
Miscellaneous	7%

A short time ago a table was published in one of the railway papers giving the number of machine tools total and of each class per erecting pit, and this showed the average to be slightly over 9 tools per pit. The table is as follows:

MACHINE TOOLS OF EACH CLASS PER PIT.

Lathes	3.925
Boring Mills	.875
Planers	1.00
Shapers	.5
Slotters	.458
Millers	.375
Drills	1.083
Grinders	.666
Miscellaneous	.708
Total	9.59

Various tables have been published showing the number of tools of each type and size for different numbers of pits, but they are usually more interesting than valuable because of the differences in local conditions. The table above is merely a guide and not a safe and invariable rule, although it is based upon average shops. For boiler shops the average is about one tool for every pit in the erecting shop, there being seldom more than one tool of each kind aside from drills and shears.

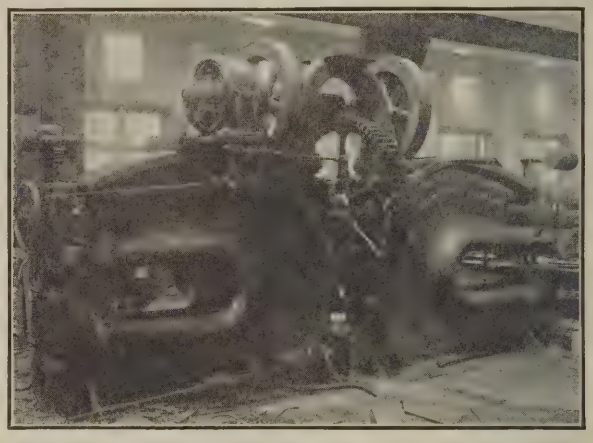
The policy of the management regarding the stocking of repair parts and the degree to which standardization has been carried have a great influence upon the number of machine tools required. More tools will be necessary to get out work in a hurry if the stock is too small and fewer tools will be required for ordinary operation if parts are standardized fully. Special machines may be used also if parts are standard.

CAR SHOPS.

Most railway shops comprise freight and passenger car shops and are equipped to make new cars as well as to repair old ones. The requirements in each case are similar, the materials being in a large measure the same. But the arrangements of the two are different, so we will consider them separately. They should both be near the mill, storage yard, truck shop, car machine shop, foundry and blacksmith shop and be well provided with tracks of both standard and industrial service types.

In freight car shops longitudinal tracks are preferable, with material tracks between, the main tracks being placed on from 20 ft, to 22 ft. centers. In modern shops making heavy cars the use of overhead cranes is being adopted, especially where steel cars are either made or repaired. With four tracks the span of the crane will be 90 ft. and with twenty cars per track the building will be 1,000 ft. in length, allowing 50 ft. per car.

Passenger car shops usually have the tracks running crosswise and are from 90 ft. wide for one car per track up to 225 ft. wide for three cars per track, with a transfer table along the outside. The paint shop is usually at the opposite side of the transfer table from the coach shop and must be kept free from dust and dirt. Both of these shops require plenty of light and ventilation, some recent shops having window and skylight areas combined equal to the floor areas. Plenty of artificial light must also be provided.



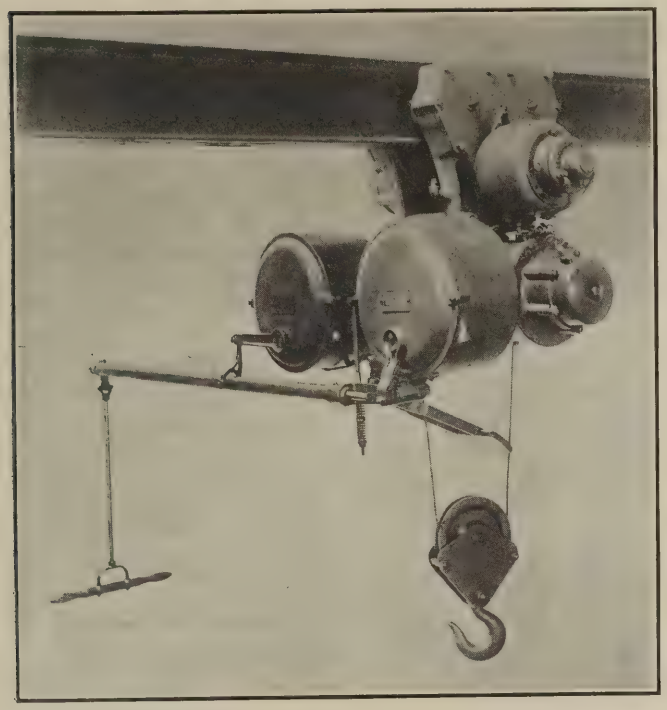
Combination Motor Driven Punch and Shear.

Owing to the necessity of keeping the working force together during the slack period of each year most roads do a certain amount of new car building. This will influence the equipment but a very little because of the nature of the work done anyhow. Only one American road makes its own paint, the others preferring to buy it, although several of them do their own mixing. Adjustable scaffolding is used in all of the newer shops and most of them have concrete floors. The transfer tables are electrically operated in the majority of cases, although a few of the older shops still use steam. The preferred location for the trolley wire is overhead and above the center line of the pit.

BLACKSMITH SHOP.

The blacksmith is another of the departments common to all of the other shops and should be located in as central a position as possible. At the same time it should be isolated as much as it can be in order to provide plenty of light and air, rather than made a part of some other building. It should be near the car and locomotive shops and not too far from the scrap yard and storehouse. In arranging the equipment inside it is desirable to keep the car and locomotive divisions separate because of the essential differences in the work required. This has re-

sulted in making some blacksmith shops L-shaped, with one end near the locomotive shop and containing the large hammers and furnaces and the other near the car department and containing the smaller machines such as



Typical Electric Trolley for Shop Telpher Systems.

bolt headers, shears, etc. In most cases, however, a rectangular building is satisfactory.

Until recently swinging jib cranes were considered satisfactory for smith shops but in many late shops overhead cranes have been installed with the cages hanging low enough to protect the operator from the gases and smoke. Aside from the cranes and a few motors for driving punches, shears, etc., there is no electrical equipment used in blacksmith shops. Blowers for the furnaces are also motor driven in modern shops, velocities corresponding to pressures of 8 or 9 ounces being used for the blasts. Oil is also superseding coal in modern shops for fuel, and reduces the amount of fumes.

FOUNDRY.

Prior to ten years ago foundries were not found in many railway shops, but recently the larger shops have practically all been equipped with foundries, especially for grey iron. Wheel shops are also found in many plants for making chilled car wheels in large quantities. None of the railroads have steel foundries or malleable iron foundries, although most of them have brass foundries. These are generally in the same building with the blacksmith shop but kept separate by means of a brick wall, but when an iron foundry exists it is a part of that building. The pattern shop should be located near the foundry and the patterns kept in a fire-proof building if possible. The foundry should be near the store house and castings storage yard, with good provisions for receiving raw materials.

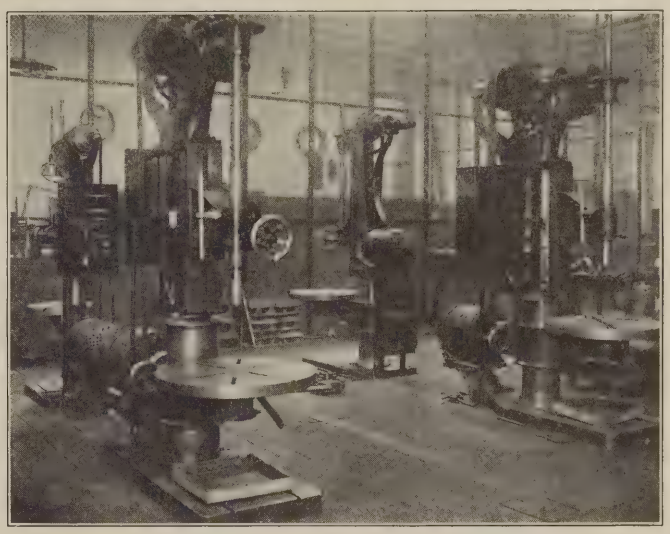
Every foundry should be provided with plenty of cranes for handling heavy flasks and castings. These should include a large one overhead in addition to several jib cranes along the walls, the latter being arranged so that they may be lifted by the overhead crane and moved from place to place to accommodate production. Easy means for transportation between the foundry and locomotive machine shop must also be provided on account of the large number of heavy castings required there.

The entire main floor should be available for moulding, and industrial tracks with turntables at the corners of the room should be installed. This should connect with the system of tracks in the storage yard to facilitate handling pig iron, scraps, coke, etc. An industrial track with a scale should be provided on the charging floor and an elevator must be added to raise material. Space should also be left for enough material to last at least one day in case of emergency.

Foundries for railway shops are usually equipped with two cupolas of 18 or 20 tons capacity each and are generally placed so as to be charged from the same floor. They should be placed in a side bay in such a way as to be within reach of the main traveling crane, when tapped. The fans, furnaces, core rooms and ovens, moulding machines, etc., are usually in a side bay also. Cranes of 10 tons capacity are most commonly used in railway foundries with hoists of from 1 to 5 tons capacity in the side bays.

PLANING MILL.

The obvious location for the planing mill is between the lumber yard and dry sheds and kiln on the one hand and the car shops on the other. The lumber yards are usually quite large and placed at one end of the yards and the freight car shops use most of the material, so the location of the mill becomes easy. Several other departments use more or less finished lumber, notably the passenger car and locomotive cab shops, so convenience of access to them must also be considered.



Typical Individual Drives with Automatic Starters.

The mill building should be rather long in proportion to its width and a large percentage of the floor area should be left for handling material. The very general use of electric motors for driving mill machinery, either individually or in groups, has had its effect in simplifying the buildings somewhat, for engine and boiler annexes are no longer required. The waste from the mills is still used for fuel in the boiler room of the main power plant, provision for this usually being in the form of a hand-fired boiler. Ample natural lighting should be provided.

Material should progress through the mill in a straight line and this is best accomplished by placing the heavy machines on one side of the room and the lighter ones on the other. The material should come first to the roughing machines, then the intermediates and finally to the finishers, but should be kept off the floor as much as possible. Skids and trucks are very convenient for this. The machines comprise planers, saws of various kinds, mortisers, tenoners, moulding machines, boring machines, gainers, matchers, etc., the larger ones being best driven individually with motors.

STOREHOUSES.

Every railway shop should have a large general storehouse with local store rooms in each department to save time. The general storehouse should be provided with outside platforms at the level of the car floors and be divided into sections for each kind of material. The department store rooms or buildings should contain the

Typical Air Operated Jib Cranes for Forge Shops.

things used in each department such as lumber, iron and steel, castings, wheels, frames, etc., and small cranes should be provided for handling this material. Plenty of bins, racks and boxes should be provided for assorting and caring for this also.

The storehouse is such a large item in any railway shop that it is worth a separate article for an adequate description, so we will not attempt to give much detail here. However, the location of the building should be such that it is convenient to all other departments, should be next to the main highway of intercommunication and large enough to accommodate all of the material without crowding. It may be several stories in height, if elevators are provided, and should be fireproof.

MISCELLANEOUS.

The round house or engine house is really a sort of locomotive repair shop with a turntable in the center and is used for light repairs on locomotives to keep them in service. Its value depends upon the facility with which this may be done, so several roads follow the practice of having small but well equipped repair shops adjoining them. There is no standard yet for roundhouses, although they are all on the same general plan, and they vary from about 200 ft. in diameter up to 350 ft. according to the number of stalls.

Coaling stations, sand houses, cinder pits, turntables and other auxiliary buildings are required for all shops, but will not be described here as they contain nothing of interest to the electrical men. The turn table is a possible exception as it is usually motor operated. Series motors are used with controllers similar to the equipment on a street car.

For large areas, such as locomotive machine shops, foundries and yards, the flaming arc lamp is best suited because of its high power and great penetrative ability. Mercury vapor lamps are used to some extent in medium sized shops and power plants, and tungsten lamps of various capacities, singly or in groups, are used to an increasing extent in machine shops, mills, power plants and many other places where there is no smoke to penetrate.

The best system of illumination for large shops is a combination of flaming arc lamps for general illumination with tungsten clusters for group lighting and incandescent drop lights for machines. The individual lighting of machine tools is very important and is receiving more attention now than formerly. Good lighting consists in throwing the light on the work and not in the eyes of the worker. Any system which will do this and supply light enough to see clearly cannot be a very bad system, even though it be not perfect.

Flaming arc lamps make good illuminants for yards and roadways about the shops and plenty of them should be installed to prevent accidents. This is especially important where switching is being done at night if pedestrians are passing. They are also best in foundries on account of the smoke in the air, as also in blacksmith shops.

For the offices, drafting rooms and stations the indirect system of lighting is coming forward rapidly on account of its efficiency and very pleasing appearance as well as its freedom from glare. Carbon filament lamps stand the handling as drop and portable lights better than the tungsten filament, although the new drawn wire type is much more rugged than those first made. Guards should be placed on all portables to protect them and to reduce the danger of fire.

As stated in the beginning, this is such a large subject it cannot be covered in a single article like this, but we hope there has been something of interest herein for everybody.

Typical Modern Car Shop, Showing Construction.

For information regarding the proper machine tool equipment to use in each department, the reader is referred to the article on the "Big Four" shops in this same number of the RAILWAY ELECTRICAL ENGINEER. This is one of the most recent and up-to-date shops in America, and the equipment is typical of the most approved practice. Lists of tools for the various departments are given at the end of that article which will be helpful.

Consolidated Company Exhibits New Regulators.

The Consolidated Ry. Elec. Lt. & Equip. Co. is exhibiting their Type "D" and "F" axle lighting generators and their new Type "L" lamp regulator at their Booth No. 614, out near the Convention Hall, on the Million-dollar Pier.

A New Type of Roundhouse Lighting

In making plans for the new roundhouse of the C. & N. W. Ry., at Butler, Wis., the management of that road decided to make comparative tests of some of the various systems of illumination suitable for this purpose. Five different systems in all were installed on trial, one of which is so radically different from any previous types of roundhouse lighting systems that it merits special consideration. Incidentally this was the one that gave the most satisfactory service and has since been adopted by that road as standard practice.

Fig. 1. Showing Roundhouse Reflectors on the Wall.

It employs of a special reflector designed by the Crouse-Hinds Co., for this service. This is really a modification of their street car headlight. These are mounted on the wall about 8 ft. from the floor as shown in the accompanying diagrams and illustrations. Two of the units are mounted at the further end of the aisle between stalls and one at the rear. A bull's-eye lens is placed in front of the lamp so that an effective distribution of the light is obtained. The distribution curve of this unit is such that it gives a rather strong side light providing for a good illumination on the work benches along the wall and in the runway in front of the stalls and at the same time projects a powerful beam directly down the aisle between engines. It would seem, however, that if these units were mounted on wedge shaped blocks so as to direct the main flux of light from one unit diagonally across the aisle onto the motion parts of the engine opposite and vice versa, a better illumination and more effective elimination of shadows would result.

Although the lighting fixtures installed were of five different systems, a permanent installation of wiring in galvanized steel conduit was made. The roundhouse which is one of the largest built, making a complete circle, is divided into two main circuits, each of which feed from a 7½ k.w. transformer mounted on poles on opposite sides of the roundhouse. From each of these transformers the main circuits are led as a three wire 110-220 volt system to a panel distributing board. There are 10 circuit switches on each panel, each of which provide for lighting three stalls. These wires are placed in conduit which is of tapering section. That is, the first third of the run is in 1½ in. conduit, next 1 in. and then ¾ in. At each of the stalls a four way condulet is placed so as to permit of tapping in each individual stall circuit. A push button condulet switch is placed at each stall so that any one of the stalls may be lit or turned off as desired. The light at the rear end of the stall is also controlled by this switch and the wiring is carried through pipe conduit on the roof trusses. A plug for a drop light is installed on the forward post of each stall so as to provide a drop light for use in the cab and inside the boilers.

The five systems installed on trial were as follows:

(a) 2 Crouse-Hinds roundhouse reflectors, each with a 40 watt tungsten lamp at the forward end of the stall and a similar reflector at the rear.

(b) 1 Crouse-Hinds roundhouse reflector with 40 watt lamp at the forward end of stall and one at the rear.

(c) 1 Crouse-Hinds roundhouse reflector at forward end of stall and one 60 watt lamp in flat cone reflector at the rear end of the stall.

(d) 2 Crouse-Hinds reflectors with 40 watt lamps at the forward end of the stall and one flat cone reflector with 60 watt lamp at the rear.

(e) 1 60-watt lamp in flat cone reflector at the forward end and one 60-watt lamp in flat cone reflector at the rear.

Of these five installations the one having 3 Crouse-Hinds roundhouse reflectors seems to give the best illumination on the parts where that illumination is most needed and because they are placed low, out of the smoke zone and where they are accessible and the cleaning is a simple matter, the reflectors seem to be particularly well

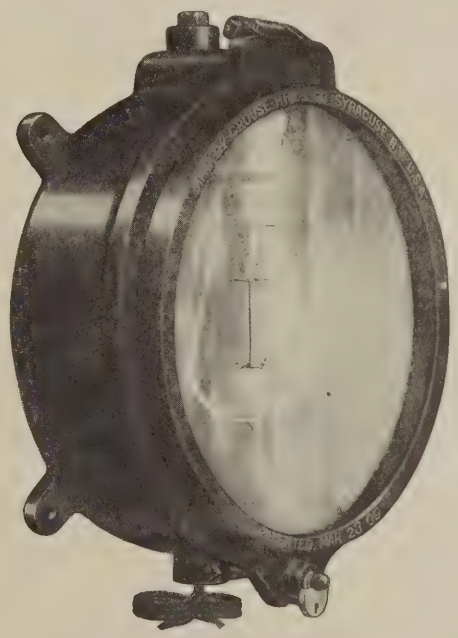


Fig. 2. Roundhouse Reflector.

adapted to roundhouse lighting. The benches along the wall of the aisle in front of the stalls are well illuminated, while the main beam of light was projected right down on the motion parts of the engine where repairs are most often made.

Installation (b) using two of these reflectors only, one at the front and one at the rear, seems to be hardly sufficient although it is understood that further modifi-

cation of this reflector will be made so as to accommodate a 60 watt lamp which will give more intense lighting. The flat cone reflectors, while they give better illumination in the ailes in front of the stalls, do not

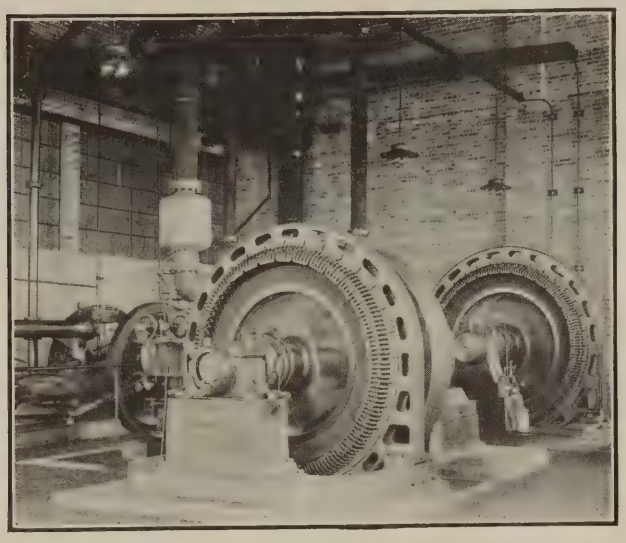


Fig. 3. Engine Room Butler Roundhouse C. & N. W. R. R.

seem to light up the motion parts of the engines quite as well as the Crouse-Hinds roundhouse reflectors do.

This roundhouse is designed to take care of freight engines on the cutoff around Milwaukee and has a total of 58 stalls, one of the largest roundhouses made. A small but well equipped machine shop is provided so that a certain amount of repairing can be done right on the spot. To provide power for these motor driven tools as well as two large motor driven ventilating fans, coal hoists, well pumps, roundhouse lighting, etc., a complete little power house with the following equipment has been installed.

1 200 k. w., 480-volt, 3-phase a. c. G. E. generator, direct connected to a 225-h. p., 4-valve Ball engine of 225 r. p. m.

1 200 k.w., 480-volt, 3-phase a, c. G. E. generator, 200 r. p. m. direct connected to a 317-h.p., 4-valve Russell engine.

1 marine engine generator set 10 k. w., 125 volt, d. c.

1 10-k.w. motor generator set 125 volt d. c. 440 3-phase a. c. induction motor speed 1800.

650-h.p. boilers.

1 air compressor.

4 panel switch board, as follows:

(a) Engine No. 1, (b) engine No. 2, (c- feeder, (d- exciter. A Tirrell regulator is provided for maintaining constant voltage of the alternators and the usual number of ammeters, voltmeters, and circuit breakers are supplied.

GRADUATE SCHOLARSHIPS IN ELECTRICAL ENGINEERING AT THE MASSACHUSETS INSTITUTE OF TECHNOLOGY.

The Committee on Graduate Scholarships has recommended scholarships for Messrs. R. D. Huxley A. L. Matte, L. C. Tomlinson, E. L. Bray and H. E. Dexter who are candidates for advanced degrees in Electrical Engineering at the Massachusetts Institute of Technology. Three of these young men are candidates for the degree of Doctor of Engineering. The popularity of the post graduate study of Electrical Engineering at the Institute continues to increase. A number of Master's degrees in Electrical Engineering will be granted this year in addition to fifty or more Bachelor's degrees.

CAR CLEANING EN ROUTE.

With the advent of the portable vacuum cleaner, the problem of cleaning cars of through trains becomes a much simpler one. Formerly at division points a few car cleaners invaded the Pullmans and observation car with broom and dustpan much to the discomfort of the passengers. With the improved portable vacuum cleaner, however, this can be done very easily at any time by the porter in the car with but little inconvenience if any, to the passengers.

The portable cleaner shown in the accompanying illustration is one of a new type especially designed for railway car service, in that it is light and very compact, requiring only about the same space an ordinary broom

Vacuum Cleaner in Service.

would occupy, so that it can be placed on the back of any locker door.

For general cleaning such as floors, seat cushions and backs, the hose is detached and the cleaner itself is used.

All mechanical parts with the exception of the motor are of highly polished aluminum so as to give an attractive appearance. A dust proof bag collects all the dirt which is picked up, and is emptied by the car cleaners in the terminal coach yard.

Though small, the Utility electric cleaner shown herewith has a very powerful motor and is fully as effective as many of the larger and heavier types.

Motors are supplied to operate on any of the standard car lighting voltages of 110, 64 or 32. A 110 volt, a. c. motor can also be furnished for office or depot service.

Voltage-Current Controlling Regulator

SAFETY TYPE "F" EQUIPMENT

It is a well established fact that if a lead battery has a voltage of 2.5 volts per cell impressed across its terminals it will automatically take a charge best suited to its needs. That is, the charge will start at a high rate and will automatically taper to nearly zero as the battery becomes full, corresponding to a stop charge.

Where the size of the generator unit is necessarily limited, as in the case of the car lighting generator, the high current flow at the beginning of this charge, particularly when the lights are on, would be far in excess of the capacity of the generator; it is therefore necessary to prevent the generator from being overloaded under such conditions. This is accomplished in a type "F" regulator by a combined current and voltage control, the current control being effective at the beginning of charge and prevents the generator from being overloaded excessively, while the voltage control becomes effective near the end of charge and operates to diminish the battery charging current to a low value when it is no longer needed.

Type "F" Dynamo Regulator.

The dynamo regulator consists of two pieces of apparatus, the field regulator and the main switch. The main switch is of the closed magnetic circuit form with

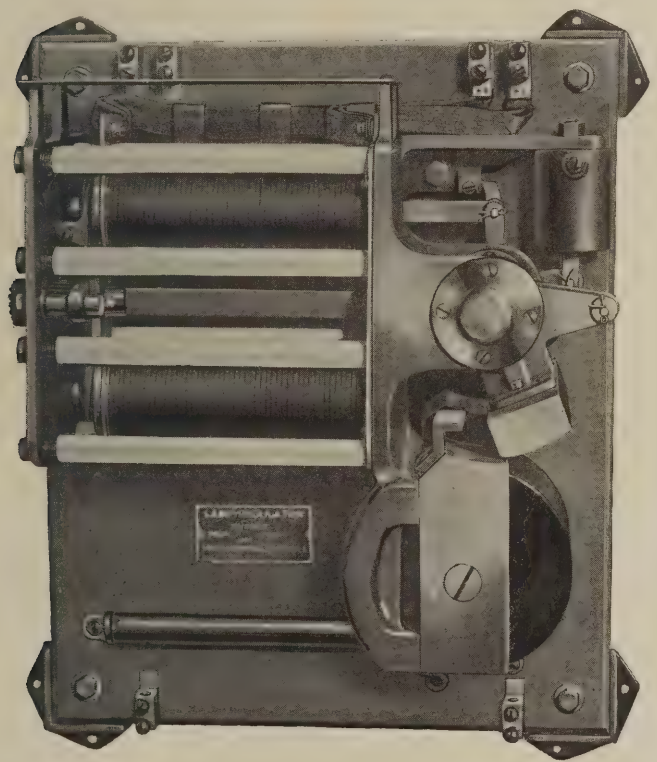


Fig. 1. Type "F" Lamp Regulator.

hinged armature carrying a heavy laminated copper contact, the whole being of the same design that is universally used for contactors for street railway work and in circuit breakers and other switch apparatus.

The field regulator consists of two coils, a series coil carrying the total generator output, and a voltage cell, connected directly across the generator and subject at all times to generator voltage. The plungers of these two coils, acting through independent levers, vary the pressure on the field resistance carbons, giving the proper field current strength to regulate the generator output for all conditions of speed and battery charge. The voltage coil prevents the voltage impressed on the

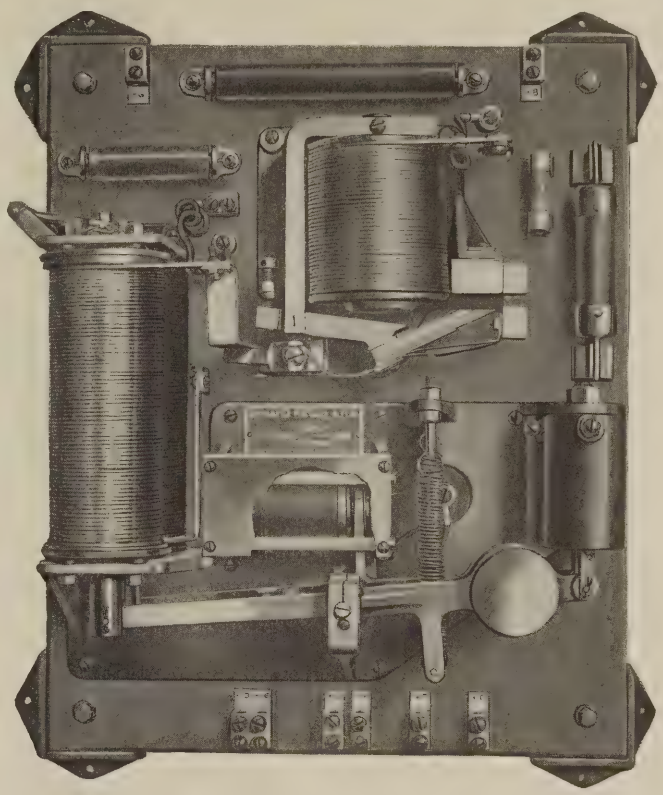


Fig. 2. Type "F" Dynamo Regulator.

battery rising about 40 volts and the series coil prevents the total current given out by the generator rising above its desired output.

The operation of this is essentially the same as the type "D"; that is, the generator is completely protected against overload, the batteries can never be overcharged, and at the same time, when the batteries are empty, they can be charged in the minimum length of time. This result is accomplished with two pieces of apparatus on the regulator instead of three as on type "D".

Type "F" Lamp Regulator.

In order to emphasize the importance of accurate lamp regulation, it should be noted that if the voltage delivered to an electric lamp drops 3 per cent below normal, the available candle power of the lamp drops 10 per cent; if the voltage drops 5 per cent the candle power drops 18 per cent. If the voltage on the lamps is 3 per cent above normal, the life of the lamp is reduced 33 per cent, and if the voltage is 5 per cent above normal, the life is reduced 50 per cent. It has been the aim of the Safety Company in the design of lamp regulators to accomplish the closest possible lamp regulation with the fewest number of parts.

The Type "D" lamp regulator has demonstrated in service that it is possible to satisfactorily regulate the

lamp voltage by using a carbon pile resistance in series with the lamps, an electro magnet regulating the pressure upon this carbon pile and a control apparatus controlling the strength of the electro magnet and causing it to respond to variations in lamp voltage. The type

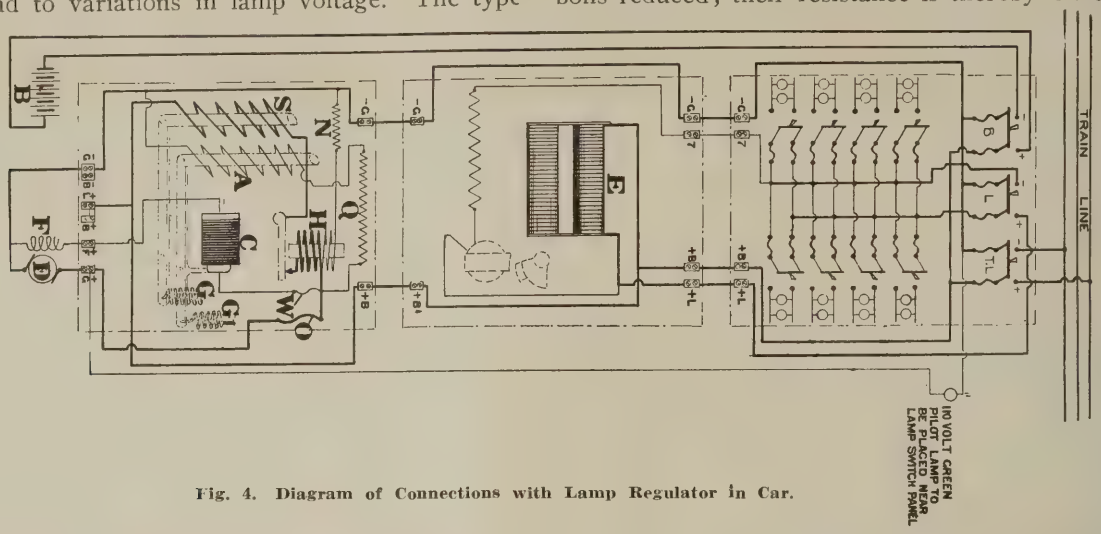


Fig. 4. Diagram of Connections with Lamp Regulator in Car.

"F" lamp regulator is a perfected type "D", the same regulation being accomplished without a means of control exterior to the lamp regulator proper. The actuating magnet is connected directly across the lamps; the regulator is so carefully designed and built that it will respond to the smallest variations in lamp voltage.

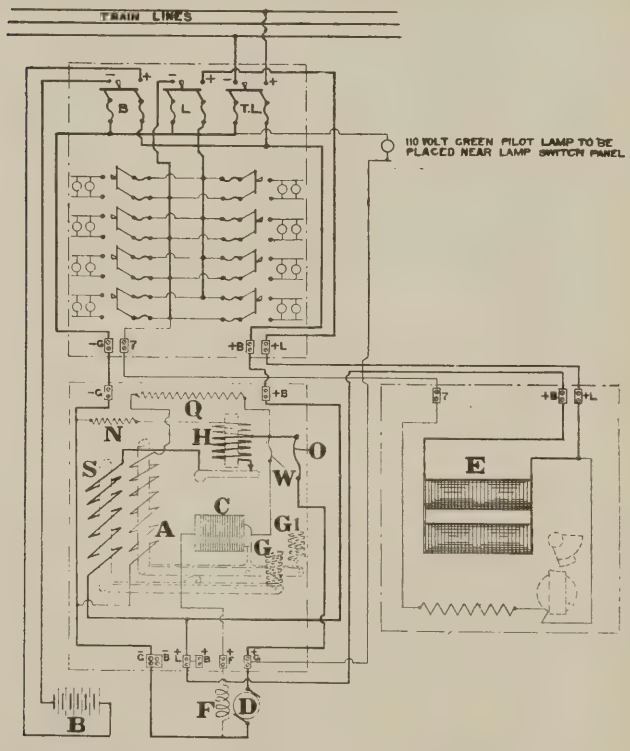


Fig. 4. Diagram of Connections with Lamp Regulator under Car.

The type "F" lamp regulator consists of two carbon pile resistances connected in series with the lamps. The carbons are compressed by a coil spring, which is connected by a link, acting through a toggle mechanism to the armature of the actuating magnet. The pull of the spring is opposed by the pull of the electro magnet. The coil of this magnet is connected directly across the lamp mains. The pull of the spring is adjusted so that it will balance the pull of the magnet through its stroke when the lamp voltage is at the desired value. Mechanical friction and hysteresis are reduced to low value by careful design and the use of the proper materials of construction.

If the lamp voltage is increased, the pull of the electro magnet is increased and the pressure upon the carbons reduced; their resistance is thereby increased until the lamp voltage is again normal. If the lamp voltage is reduced, the opposite action takes place, the magnet being weakened and the carbons more tightly compressed, reducing their resistance and bringing the lamp voltage back to normal.

The type "F" lamp regulator is one simple piece of apparatus and, consisting as it does of only a carbon pile in series with the lamps and a magnet connected across the lamps, there is absolutely nothing to get out of order. The operation is very simple, and most reliable, because the voltage regulation depends only upon the balance between a magnet pull and a spring pull, without the use of any control apparatus such as carbon pile, controls, buzzers or vibrators.

ANNUAL PASSES FOR OLD EMPLOYEES.

As a reward for faithful service, the Management of the Missouri Pacific-Iron Mountain Railroad has decided to issue annual passes to employes who have worked for that company fifteen years or longer.

About 1,500 employes will receive these passes, including Agents, Conductors, Engineers, Brakemen, Train Baggagemen, Switchmen, Firemen, Hostlers, Telegraphers, Bridge & Building Foremen and Section Foremen.

The rules covering the extension of this courtesy to employes are: For fifteen years continuous service an employe receives annual transportation for himself over the division on which he is employed; for twenty years continuous service an annual pass for himself and wife over the division, and after twenty-five years continuous service annual transportation for himself and wife over the entire Missouri Pacific-Iron Mountain System of nearly 7,300 miles.

CIRCUIT BREAKERS.

The type F circuit breaker manufactured by the Westinghouse Elec. & Mfg. Co., is described in folder No. 4049.

These breakers are designed for 250 volt alternating current and 440 volt direct current. They are equipped with the usual carbon break points and are made in various types including automatic overload release with shunt trip coil, and non-automatic with shunt trip. Reverse-current trip and over-voltage features can also be provided.

SHOP SECTION
EDITED BY
GEO. W. CRAVENS

Shop Series No. 13

Beech Grove Shops of the C. C. C. & St. L. Ry.

The new shops of the "Big Four" R. R. at Beech Grove, Ind., a suburb of Indianapolis, are one of the best examples of up-to-date shop building in America.

General View of Big 4 Shops.

These shops are very well laid out and equipped, the buildings are roomy and substantial and everything about the place speaks well for the men who have and have had the matter in charge. While the shops are not entirely completed or equipped, they are nearly so, and work is being done quickly, economically and well.

The general layout is based upon having a main craneway along the center of the yards, with all buildings tributary thereto, and a transfer-table between the car repair and paint shops. Reference to the layout shown herewith will show the functions and relative locations of the various buildings, and the system of tunnels connecting the power house with them for electric wiring and steam pipes. The practice of locating those buildings which have the most intimate relation with the others near the center of the group has been followed here, and the power plant, general store-house and blacksmith shop are so located.

The yard craneway spans a storage space and the transfer-table serving the car shops runs in under it far enough to be served by the main crane. Space has been allowed around the present buildings for growth and the addition of other buildings without interference, and with due regard to operation of the departments economically regardless of how large they may grow. No round-house has been provided here, it being considered satisfactory to do light and heavy repairs under the same conditions in the locomotive machine shop or in the yards. A turntable has been placed in the material and stripping yards between the boiler and tank shops with tracks running into the locomotive shop for easy access for repairs.

The buildings are all of heavy steel frame construction with brick filling-in walls and large window areas and skylights. Concrete has been used freely wherever possible, the main storehouse and office building being especially massive. The second floor of the wood working mill is of steel framing, filled with concrete and suspended from the extra heavy roof trusses. This gives an entirely clear first floor with plenty of room for handling lumber. All of the way through, these buildings are unusually well built, lighted and ventilated, and adequate space has been provided for economy in production without crowding.

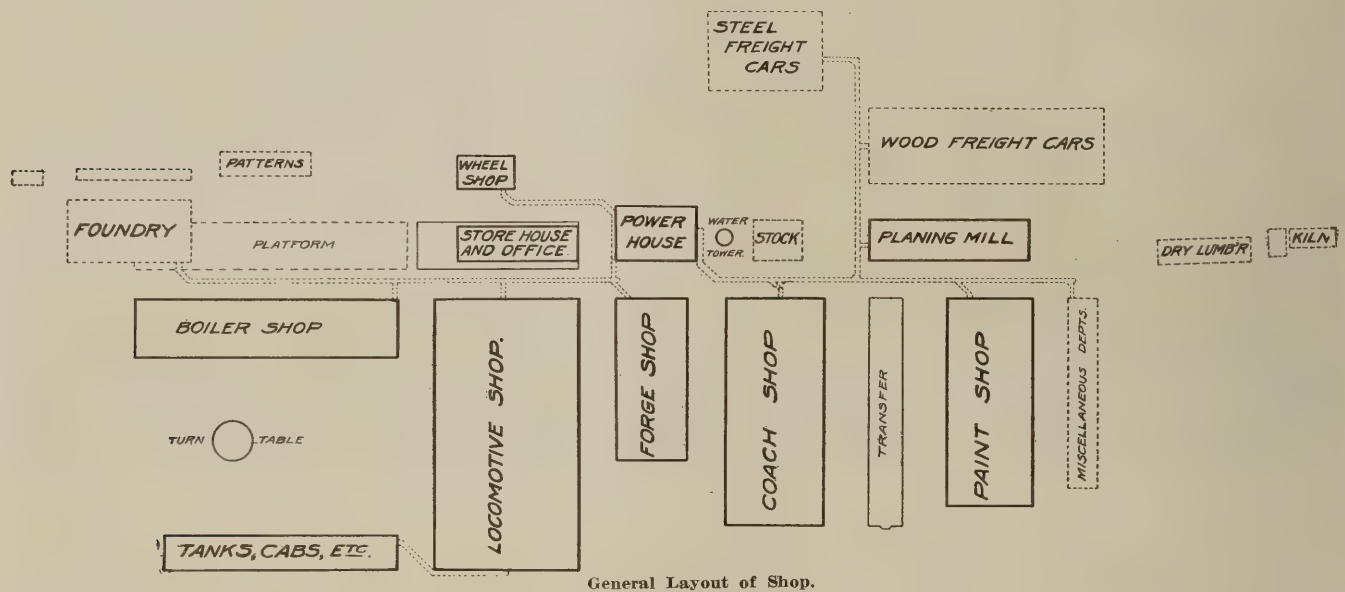
All work done in these shops is on a piece-work basis, the rates being fair and absolutely permanent, and the men earn unusually high wages and are contented. As is usual under such conditions, they are of a high class and turn out large quantities of work with a minimum of supervision and rejections. There is also an excellent school for apprentices here with from 80 to 90 boys always attending.

This school occupies two large rooms in the office building, one of which is fitted with desks and the other with drawing tables and the models of equipment and parts. The boys start in at a minimum of 17 years of age and attend four years, a certificate being given them upon the satisfactory completion of the course. Entrance examinations in spelling, arithmetic and letter writing must be satisfactorily passed and they must be of good character before being accepted. Recitations are held twice each week, of two hours each, these taking place during the morning, and four sheets of problems must be done at home each month.

All detail drawings for the shops are made by the older apprentices and they get a thorough shop training in all departments in addition to a good theoretical training in machine design, mathematics and other related subjects. The class rooms contain models of pumps, air brakes, locomotive running gears, Walschaert and Stevenson valve gears, boilers and fire-boxes and numerous others parts of locomotives and cars. There is also a heavy jack with a scale beam and weights for studying leverages. All of the models used here were made by the apprentices in connection with their studies and are substantial and well made and finished. This work is carried on under the direction of the Superintendent of Motive Power, Mr. Wm. Garstang, in accordance with a course developed for all of the shops on the New York Central Lines.

Electric power is used throughout these shops for all

machine tools, except a few air operated ones and some hoists, both alternating and direct current being used. All current is generated in the local power plant, there being a total a.c. generator capacity of 1500 k. w. at 100 per ct. power factor. The present power factor varies from 65 per ct. to 75 per ct., and the shop load factor is 33 per ct. Direct current is obtained from two 300 k. w. motor driven generators. About 10 per ct. of the total power generated is used for lighting and about 60 per ct. for cranes. Alternating current is generated at 480 volts, 60 cycle, three phase, and direct current at 125-250 volts for three-wire distribution.



General Layout of Shop.

Power Plant and Distribution System.

The power house is divided into three sections, boiler, auxiliary and engine rooms, with a basement below and a large concrete stack in the boiler section. There are 10 Babcock and Wilson 400 h. p. boilers with automatic stokers and chain grates, the stack being located near the center of the row. Coal is brought to the side of the building in hopper-cars, dropped through a chute into a Link-Belt conveyor and carried to the concrete bunkers overhead in the boiler room. From here it is fed through spouts to the hoppers of the stokers and the ashes drop into ash hoppers below the grates, from which the conveyor carries them up to ash bunkers for removal.

Intermediate between the boiler and engine rooms is the room containing the pumps, steam pipes and miscellaneous auxiliaries. All of the pumps are located in the basement, but the main floor is cut away so that it forms merely a gallery and the pump room receives good light from the skylight. The two large Webster vacuum feed-water heaters, purifiers and filters are located on the main floor, all other auxiliaries being down stairs with the pumps. The steam pipes from the boilers pass through this room to the basement under the engine room and up through the floor to the engines.

The engine room is very well supplied with windows and the arrangement of apparatus is such as to allow for considerable extension, and a large overhead crane is provided for convenient handling of heavy equipment. The switchboard is at one side of the room near the center and the machine equipment is as follows:—

3 Westinghouse-Parsons 500 k. w., 60 cycle, 3-phase, 480 volt turbo-generator sets.
2 Westinghouse 40 k. w., 125 volt, 350 r.p.m. engine driven exciters.
2 Westinghouse motor-generator sets, each consisting of
  1 450 h. p., 480 volt, 3-phase, 60 cycle induc. motor.
  1 300 k. w., 3-wire, 125/250 volt d. c. generator.
1 blue Vermont marble switchboard of 22 panels.
2 oil switch panels for motor generator sets.
2 gauge panels for steam and air apparatus.
2 air compressors, driven by horizontal cross-compound steam engines.

The switchboard is 90" high and contains Westinghouse meters and switches, all wiring is carried down through the floor and the arrangement of the panels is as follows, starting at the left:

Swinging bracket and T. A. regulator.
Panel No. 1—A.C. series arc lighting.
Panel No. 2—D.C. power and lighting.
Panel No. 3—D.C. power and lighting.
Panel No. 4—D.C. power and lighting.
Panel No. 5—D.C. power and lighting.
Panel No. 6—D.C. power and lighting.
Panel No. 7—D.C. power and lighting.
Panel No. 8—D.C. motor-generator set No. 1.
Panel No. 9—D.C. motor-generator set No. 2.
Panel No. 10—D.C. exciters.
Panel No. 11—Blank.
Panel No. 12—Blank.
Panel No. 13—A.C. generator No. 1.
Panel No. 14—A.C. generator No. 2.
Panel No. 15—A.C. generator No. 3.
Panel No. 16—Totalizing panel.
Panel No. 17—A.C. power feeder.
Panel No. 18—A.C. power feeder.
Panel No. 19—A.C. power feeder.
Panel No. 20—A.C. power feeder.
Panel No. 21—A.C. power feeder.
Panel No. 22—A.C. power feeder.

All wiring for power and lighting in the shops is carried from the power house to the various buildings underground. The first cables laid were rubber covered and lead sheathed, single conductor for d.c. power and 3-conductor for a.c. power, all run in single-bore vitrified ducts installed alongside the tunnel wall and terminating in manholes opposite each building. All of the later cables are paper insulated and lead sheathed, single conductor for d.c. and 3-conductor for a.c., the same as the older ones, but run in multiple bore vitrified ducts for simplicity in installing. The wiring diagram given

herewith shows the distribution system in such detail that it is not necessary to describe it otherwise, but it is worthy of note that all buildings are wired on the "loop" method in order to provide against failures.

At the end of each building is a manhole containing a main distributing panel controlling both the 440 volt a.c. and the 110/220 volt d.c. circuits. From here the

Power House, Store House and Office Building and Yard Craneway.

risers go up through iron conduit and along the roof trusses or walls, as the case may be, on insulators, with all branches carried in conduits. Tie panels are also installed at the ends of the buildings to complete the loops, separate risers being run up from the main distributing panels for the crane trolleys where cranes are used, with tie panels for crane feeders also. This method has been followed for both a.c. and d.c. wiring throughout.

Plug receptacles have been freely placed at all points in every building where there may ever be any desire to use a portable lamp or small tool. Plugs with packing house cords 35 and 50 feet long are provided and fitted with sockets and lamp guards. All wires for branch circuits are rubber covered and run in conduits, with Condulet fittings and porcelain bushings at all outlets. The entire installation is absolutely first class in every respect and nothing of real value seems to have been overlooked.

Nearly all of the machine tools in these shops were bought new, very few of the old ones being brought from the Brightwood Shops which burned. Thus, they are all fitted with suitable motors and are in first class condition, most of them having been bought in 1907 and the balance in 1911. Three phase induction motors are used in nearly all places where constant speed is required and direct current motors in nearly all places requiring variable speeds. Most of the a.c. motors were bought from the General Electric Co. and most of the d.c. motors from the Westinghouse Co.

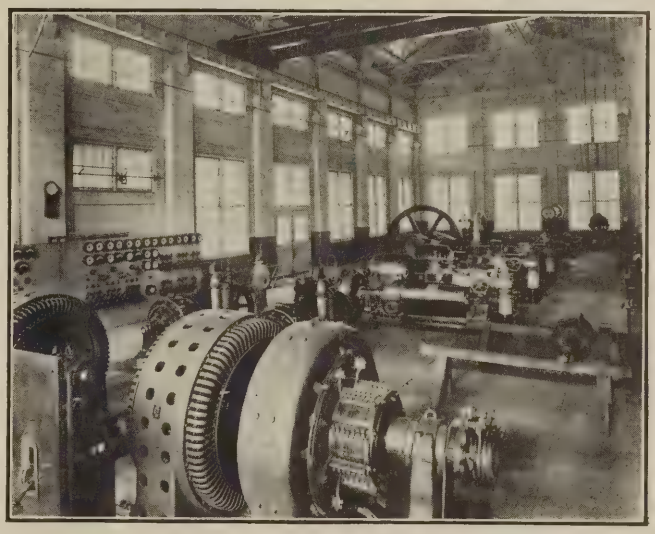
The wiring to the motors at the machines is run in conduits embedded in the floor concrete after the machines were located. In nearly all cases fuse blocks are placed near the feeder cables in every branch circuit running to a motor, each block being in an iron box tapped to take the conduit. Motor starting panels are located near the motor driving each machine not in a group, those for a.c. motors having starting compensators and those for d.c. motors having drum controllers, or dial switches, and resistances. Iron grid resistances are generally used, they standing continuous heating better than any other kind.

Cooper-Hewitt mercury vapor lights are used in some of the shops, but most of them are quipped with single tungsten, 250 watt lamps with porcelain enamelled steel reflectors. Further reference will be made to the lighting system.

Locomotive Machine Shop.

The locomotive machine and erecting shop is the largest of all, as is usually the case, being 310 ft. wide by 575 ft. long. It is divided into 5 bays, the center one being 40 ft. wide and containing a gallery full length and width. In this bay are all of the machine tools used on locomotive work, the smaller ones being arranged in groups and driven from short line shafts and the larger ones having individual motors. Up on the gallery or second floor of the machinery bay are located the sheet metal department and the tool room, together with two enormous wash rooms and toilets, three sets of engine driven blowers for the heating system, each consisting of two large fans, and a small electrical repair shop.

The two intermediate bays, one each side of the center, contain a few large tools such as lathes and planers ranged alongside the center bay, and short tracks for



Engine Room in Power House.

storing wheels and trucks from the locomotives while being repaired. A wide aisle runs along the center of each intermediate bay containing a track, and a 10 ton crane spans each of them. These bays are each 65 ft. wide and, together with the central bay, are covered with a saw tooth roof.

The two outside bays are each 70 ft. wide and contain the locomotive erecting floors and pits. Each of these bays contains a 120 ton crane and a 10 ton crane, the latter running on a lower track than the former. Each 120 ton crane has two hoisting trolleys. There are also several small jib cranes in the intermediate bays with air hoists for handling heavy parts for the machine tools. The large wheel lathes are equipped with variable speed d.c. motors with drum controllers and circuit breakers. All wiring to tools is in conduits embedded in the floor and Cooper-Hewitt lights are used for general illumination. There is no local illumination provided excepting by means of the portable lights on long leaders. Receptacles for extension plugs are provided for this purpose.

The locomotive shop is really three buildings with two covered yards between, somewhat as at the Sayre, Pa., shops of the Lehigh Valley R. R., the main difference being that the Sayre shop has five bays instead of three. The capacities of the cranes at Beech Grove are as follows

2 120 tons each, over erecting floors in outer bays, each with
- 1 bridge motor, 45 h.p.
- 2 hoist motors, 45 h.p. each.
- 2 trolley motors, 15 h.p. each.

4 10 tons each, 2 in erecting bays, 2 in intermediate bays, each with
- 1 bridge motor, 15 h.p.
- 1 hoist motor, 25 h.p.
- 1 trolley motor, 3¼ h.p.

Passenger Car Shops.

At present there are no freight car shops at this plant, but provision has been made to add such shops later. The coach shop and paint shop are at one end of the main craneway with their own transfer table between, and are 177 by 442 ft. in size, each. Each side of the transfer, outside of the buildings, are short tracks of sufficient length to take one long coach, these being continuations of the tracks inside the shops. The coach shop is divided into 5 bays, somewhat like the locomotive shop, the center and two outside bays having traveling cranes overhead and the intermediates having adjustable scaffolding for car workers.

This building is well lighted by large skylights and has a concrete floor throughout. Across the two ends of the building are subsidiary departments, the truck department being in the north end with a cross running traveling crane and the upholstery, sheet metal and electrical departments for car equipment in the south end. The method of operating is to run the cars into the intermediate bays, remove the trucks, if necessary, and

Portion of Machine Tool Bay of Locomotive Shop.

run them to the outside bays for light work. If they require general overhauling they are carried to the north end by the cranes.

At one side of the truck section is a motor driven wheel lathe for car wheels, this being electrically driven by Westinghouse variable speed d.c. motor controlled by a solenoid switch type automatic starter. For reducing the speed when approaching a hard spot in a wheel, there is a push button mounted on the lathe frame which cuts out a part of the field rheostat at the will of the operator. A smaller motor is also provided for operating the tail stock.

An interesting feature of this shop is the method of operating the cranes. They are all equipped with electric motors for each direction of travel, etc., but instead of having an operator up in the cage there are nine cords run down to a panel board. This board is horizontally mounted, has a hole for each cord to pass through and each hole is marked according to the function of each cord. Wooden handles are attached to the lower end of each cord, and the uses of the cords are as follows:

Bridge—forward and back.
Trolley—right and left.
Hoist—raise and lower.
Switch—in and out.
Circuit breaker—close.

The circuit breaker is arranged to open on failure of voltage and must be closed before pulling any of the

View of One Intermediate Bay in Locomotive Machine Shop.

other cords. All cranes in the coach shop are so equipped, their capacities being as follows:

1 30 tons, over center aisle, containing
- 1 bridge motor, 12 h.p.
- 1 hoist motor, 32 h.p.
- 1 trolley motor, 8 h.p.

2 30 tons each, in outside bays, each with
- 1 bridge motor, 12 h.p.
- 1 hoist motor, 32 h.p.
- 1 trolley motor, 8 h.p.

1 10 ton crane in north end, for truck section, containing
- 1 bridge motor, 8 h.p.
- 1 hoist motor, 25 h.p.
- 1 trolley motor, 5 h.p.

Plug receptacles are mounted on every column along the center aisle and pipe racks are stationed outside the south end of the building.

The coach paint shop has spaces for two coaches each side of the center aisle and has two plug receptacles on each column. In both the coach repair and paint shops the steam pipes for heating are run overhead with coils or radiators on the side and end walls. Both of these shops are lighted with 250 watt single Mazda units.

Blacksmith Shop.

The blacksmith or forge shop lies between the locomotive machine shop and the coach repair shop and is 154 ft. wide by 344 ft. long. It is divided into three bays, the steam hammers and large forges being in the center section and served by an overhead traveling crane. Along the sides are several small jib cranes with hand operated chain blocks and tackle. The smaller tools, furnaces, etc. are in the side bays where bolts, springs, etc. are made. The shop office and lavatories are on a gallery at one side and stock racks are located in the yard nearby. The crane in this shop has a capacity of 10 tons and is equipped as follows:

1 bridge motor, 15 h.p.
1 hoist motor, 25 h.p.
1 trolley motor, 3¼ h.p.

Boiler and Tank Shops.

These departments are located in the two buildings at the westerly end of the yard and near the locomotive

shop, each having its own building. The Tank Shop contains very few machine tools, but since work is done here on tanks, cabs and pilots there is a small woodworking section at one end containing several machines. These are listed at the end of this article with the others. Three-phase induction motors with starting compensators and circuit breakers are used for all of the tools

First Floor of Woodworking Mill.

in this shop, except that for one of the bending rolls. This is large and has a variable speed a.c. motor with a drum controller and rheostat.

The building containing the boiler shop is larger than the tank shop, being 126 ft. by 564 ft., against 76 ft. by 504 ft. for the tank shop. It is divided into two bays with a crane in each, while the tank contains a single crane. The boiler shop contains a very complete equipment of motor driven punches, shears, presses, etc., and the following overhead traveling cranes in addition to some air operated jib cranes:

1 30 tons, over boiler section, containing
- 1 bridge motor, 45 h.p.
- 1 hoist motor, 45 h.p.
- 1 trolley motor, 7½ h.p.

1 10 tons, over machine section, containing
- 1 bridge motor, 7½ h.p.
- 1 hoist motor, 25 h.p.
- 1 trolley motor, 3¼ h.p.

The crane in the tank shop has a total capacity of 30 tons and is fitted with two hoisting trolleys, each as follows:
- 1 hoist motor, 25 h.p.
- 1 traverse motor, 5 h.p.

The bridge operating motor is of 32 h.p.

Wood Working Mill.

The building containing this department is in some respects the most interesting one in the plant. The heavier work is done on the first floor, all machines being ranged along the sides of a main aisle and being individually driven by constant speed induction motors fitted with starting compensators. The freedom from unsightly belts and countershafting is a pleasing contrast with most shops, and the room is very light and pleasant to work in. A track down the center makes the handling of material convenient, and numerous hand trucks are provided.

On the second floor is the cabinet shop and lighter wood work section. The floor is of concrete on a steel frame suspended from the roof trusses by two rows of steel inverted columns, so the appearance is that of any room with columns dividing it into sections. The massiveness of the roof trusses is strikingly apparent, they being also arched over like the roof of a train shed or armory. There is no perceptible vibration, however, when most of the machines are running. No provision has been made yet for removing the shavings, but an exhaust system is to be installed later. The machinery is of the latest and best pattern, all new in 1911, and is listed herein.

Direct heating is provided by steam coils at the sides and all wiring is carried in iron conduits from the distribution panels to the motor panels, containing circuit-breakers. The tool room for this shop is located over the lavatories and foreman's office on the first floor. Two electric elevators are installed, one at each end of the building, and single Mazda lamps are used throughout. Guards are placed around all motors and belts, and hoods over the motors to keep sawdust off of them. Fire hose is located at frequent intervals along the walls and such precautions speak well for the policy of the management.

Wheel Shop.

The main wheel shop is located in its own building north of the main storehouse and is equipped with wheel presses and boring mills. Air operated hoists on jib cranes are located near the machine tools for handling wheels, and single tungsten lamps are used for lighting. A track runs through this shop for bringing wheels in

Apprentices Class and Drafting Room.

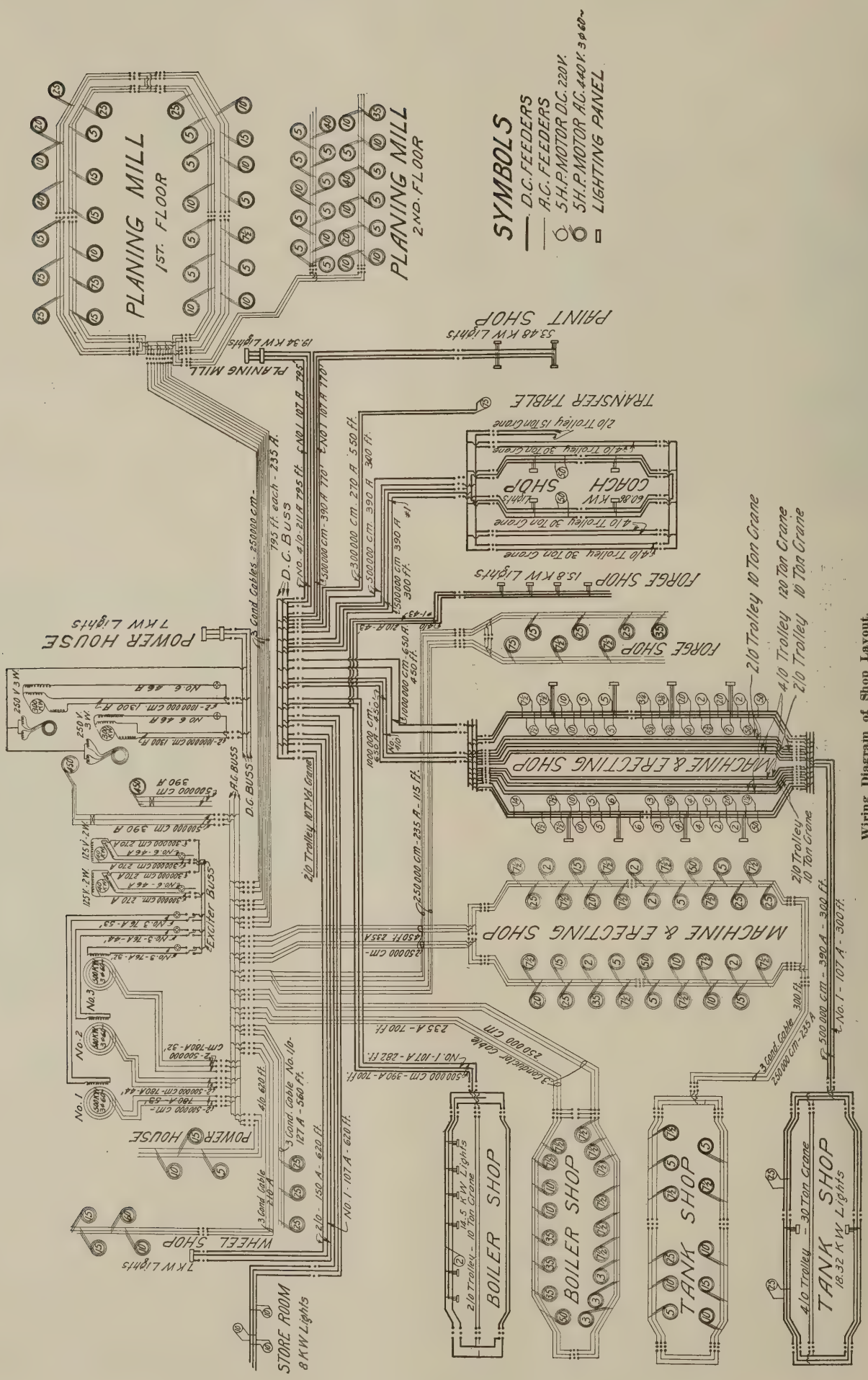
from the storage yards outside, these tracks being at right angles to the general yard track system. An air brake section is installed in one corner of the wheel shop at present, but will be moved to permanent quarters upon the completion of other buildings.

The wiring diagram herewith shows the motors in the wheel shop as being alternating current motors, but since that diagram was made it was decided to install direct current motors here on account of speed variation. This has been done for all machines herein.

Storehouse and Office Building.

The main storehouse occupies the two lower floors of the brick and concrete building to the north of the locomotive shop and alongside the main craneway. A wide platform runs along each side and extends to the west, this being on a line with car floors. Later this platform will be extended to surround a foundry which is to be built west of the storehouse. The columns and floor girders in the storehouse are of concrete, very heavy, and the floors are also of concrete with a hard finish to stand trucking.

Large racks and bins are placed in each section of the stockrooms for the various pieces and everything is in


PLANING MILL
1ST. FLOOR
PLANING MILL
2ND. FLOOR
SYMBOLS
D.C. FEEDERS
A.C. FEEDERS
5 H.P. MOTOR D.C. 220 V.
5 H.P. MOTOR A.C. 440 V. 3 ø 60~
LIGHTING PANEL
PAINT SHOP
53.48 K.W. Lights
19.34 K.W. Lights
PLANING MILL
TRANSFER TABLE
2/0 Trolley 15 Ton Crane
4/0 Trolley 30 Ton Crane
COACH SHOP
60.88 K.W. Lights
FORGE SHOP 15.8 K.W. Lights
FORGE SHOP
2/0 Trolley 10 Ton Crane
4/0 Trolley 120 Ton Crane
2/0 Trolley 10 Ton Crane
MACHINE & ERECTING SHOP
MACHINE & ERECTING SHOP
2/0 Trolley 10 Ton Crane
POWER HOUSE 7 K.W. Lights
4 Cond. Cables - 250000 c.m. - 795 ft. each - 235 A.
D.C. BUSS
4-0 - 210 A - 795 ft.
300000 c.m. 390 A 700 ft.
500000 c.m. 390 A 300 ft.
300000 c.m. 270 A 550 ft.
250000 c.m. - 235 A - 115 ft.
1000000 c.m. 650 A 450 ft.
No. 6 46 A
No. 6 - 46 A
No. 3 - 76 A - 44'
No. 3 - 76 A - 32'
No. 1
No. 2
No. 3
Exciter Buss
POWER HOUSE
WHEEL SHOP 7 K.W. Lights
STORE ROOM 8 K.W. Lights
BOILER SHOP
2/0 Trolley - 14.5 K.W. Lights
BOILER SHOP
TANK SHOP
TANK SHOP
4/0 Trolley - 30 Ton Crane
18.32 K.W. Lights
3 Conductor Cable
No. 1 - 107 A - 282 Ft.
No. 1 - 107 A - 620 Ft.
No. 1 - 107 A - 300 Ft.
3 Cond. Cable No. 1/0 - 127 A - 560 Ft.
3 Cond. Cable 2/0 A
4/0 - 150 A - 620 Ft.

Wiring Diagram of Shop Layout.

first class condition. Large windows supply plenty of light and artificial light is from single tungsten lamps. Two electric elevators connect the floors with automatic stops above and below.

The offices are on the third floor with the apprentices' school. The concrete floor has been covered with a wood floor here and glass partitions separate the offices from the main hallway. The Superintendent of Shops, Mr. R. J. Williams, and his assistants, together with the Mechanical Engineer, Mr. C. A. Brandt, and his assistants, have their offices here with Mr. M. J. McCarthy, Asst. Supt. of Motive Power.

The traveling crane over the main craneway through the yards has a capacity of 10 tons and is motored as follows:

1 bridge motor, 25 h.p.

1 hoist motor, 25 h.p.

1 trolley motor, 3¼ h.p.

The length of this craneway is approximately one-third of a mile, and rough stock of various sorts is stacked along it temporarily. This craneway forms the main intercommunicating highway between the various departments, most of which are tributary to it.

Lighting System.

Direct current is used throughout for lighting, distribution being on the three-wire system at 110/220 volts. Loricated conduits are used where necessary and open wiring where the roof construction permits. All lighting panels are with three-wire mains and two-wire branches to balance the load. After a careful investigation covering the field, the following lighting units were adopted:

250 watt clear Mazda lamps with 18'' white enamelled steel reflectors.

60 watt clear Mazda lamps with 14'' white enamelled steel reflectors.

6.5 amp. 110 volt G. E. No. 26 multiple luminous arc lamps, clear globes.

385 watt, type "P" Cooper-Hewitt mercury vapor lamps.

The lighting fixtures are all single units with steel shades and stems of proper length to suit location. Instead of using shock absorbers of the usual spring type, cushions of one inch wool felt have been placed in the upper canopies in such a way that the entire weight of the fixture rests upon them. This provides a sufficient cushion for these shops, the amount of vibration being very small.

The distribution of lights through the various shops has been done on a very liberal scale, the accompanying table of lights in a few of the shops being typical of the entire installation. The older shops, locomotive, forge, etc., have been equipped with Cooper-Hewitt lamps from the first, but the later shops have most of them been supplied with single tungstens.

General illumination only has been the aim throughout, it being felt that local illumination could best be taken care of by supplying receptacles for plugs wherever extra lights might be needed. Cables with plugs and sockets have been placed in every department for us when desired. Before selecting lamps, comparative tests were made under service conditions and the lamp best suited for each location was adopted. Cost, maintenance, efficiency and suitability were all taken into account during this investigation, and the result agrees very closely with the best modern practice.

Location.	Sq. Ft. Floor	Style and Watts Lamp	Total Number	Above Floor	Watts Sq. Ft.
Coach Shop Office..	396	Mazda 60W	5	9 Ft.	.75
Coach, Center Bay..	19200	Arc 6.5 Amp.	11	36	.41
Coach, Side Bays...	81600	Mazda 250 W	120	18	.37
Coach, Toliet Room.	1760	" 60	15	9	.51
Main Paint Shop...	79200	" 250	124	18	.39
Paint Shop Office..	870	" 60	15	9	1.03
Paint, Toilet Room.	1890	" 60	12	9	.38
Wood Mill Offices..	600	" 60	8	9	.80
Wood Mill Toilets..	600	" 60	4	9	.40
Mill, First Floor...	26457	" 250	64	16	.60
Mill, Second Floor..	26457	" 250	64	15	.61
Mill, Tool Room....	600	" 60	6	9	.60
Wheel Shop, Total..	9050	" 250	22	18	.61
Main Tank Shop....	36540	Hewitt "P"	25	35	.263
Tank(Offices, Etc..	2350	Mazda 60	22	9	.51

Referring again to machine tool control, it is the intention to place push button control switches wherever possible on machine tools for the protection of the operators. Electric drills and other small portable tools have been provided where they will be of any service, and everything that will help turn out the work quickly and properly seems to have been done.

In conclusion, the writer desires to extend his sincerest thanks to Mr. Wm. Garstang, Supt. of Motive Power, for his kindness in allowing access to the shops, to Mr. R. J. Williams, Supt. of Shops, and Mr. C. A. Brandt and their assistants for their hearty co-operation in compiling the data used herein, and to Mr. S. F. Taylor, the Chief Clerk of the Beech Grove shops, for the photographs showing the various parts of the shops.

MACHINE SHOP TOOLS.

Description	H.P.	Drive
18" Fox Turret Lathe		Belt
18" Fox Turret Lathe		Belt
Emery Wheel		Belt
18" No. 3 Monitor Turret Lathe		Belt
50" Drill Press No. 10199	5	D.C.
20" x 6' 6" Engine Lathe	7.5	D.C.
3" x 36" Turret Lathe	8	D.C.
2" x 10" Turret Lathe		Belt
2" x 24" No. 2 Turret Lathe	2¼	D.C.
2" x 24" Turret Lathe		Belt
2" x 24" Turret Lathe		Belt
2" x 24" Turret Lathe		Belt
24" x 20' 0" Shafting Lathe		Belt
28" Engine Lathe		Belt
36" Engine Lathe		Belt
42" Engine Lathe		Belt
5' Radial Drill Press	5	A.C.
30" x 9' 1" Engine Lathe	14	D.C.
16" x 6' 0" Engine Lathe	4	D.C.
16" Engine Lathe	4	D.C.
26" Engine Lathe		Belt
32" Vertical Drill Press	2	A.C.
24" Crank Shaper	3¼	D.C.
24" Crank Shaper	3¼	D.C.
28" Engine Lathe		Belt
No. 8 Floor Grinder	7.5	A.C.
24" x 5' 6" Engine Lathe	7.5	D.C.
20" Engine Lathe	7.5	D.C.
50" Vertical Drill		Belt
Bushing Press		Belt
No. 8 Floor Grinder	7.5	A.C.
No. 1 Centering Machine		Belt
20" Vertical Drill	2	A.C.
42" Horizontal B. Mill	7.5	A.C.
18" x 30" x 96" Norton Gap Grinder	25	A.C.
80" Guide Bar Grinder	10	A.C.
No. 2 Cotter Drill		Belt
18" Engine Lathe	5	D.C.
18" Engine Lathe	5	D.C.
16" Engine Lathe	1	D.C.
16" Engine Lahte	1	D.C.
50" Horizontal Borer		Belt
Slab Miller	50	D.C.
No. 885 24" Shaper		Belt
14" Engine Lathe		Belt
28" Engine Lathe		Belt
30" Engine Lathe		Belt
Vertical Boring Mill	11¼	D.C.

No. 3 Vertical Miller	10	D.C.
20″ Vertical Slotter	10	D.C.
18″ Slotter	5	D.C.
60″ Radial Drill	5	A.C.
24″ Slab Miller No. 81		Belt
6′ Radial Drill	7.5	A.C.
72″ x 72″ x 36′ 0″ Planer	50	
	7½	
	5	A.C.
1½″ Thread Cutter		Belt
1½″ Thread Cutter		Belt
6 Spindle 1½ Nut Tapper		Belt
20″ Vertical Drill Press	2	A.C.
4′ Radial Drill Press		Belt
6′ Radial Drill Press		Shaft
90″ R. & L. Quartering Machine	3&3	D.C.
96″ Wheel Lathe	50	D.C.
Nut Facer		Belt
No. 8 Floor Grinder	7½	A.C.
42″ x 42″ x 16′ Planer	2&20	D.C.
48″ x 48″ x 18′ Planer	20&2	D.C.
36″ x 36″ x 12′ Planer	10	A.C.
84″ Wheel Lathe	50	D.C.
72″ Wheel Lathe	13	D.C.
24″ x 24″ x 13′ 0″ Planer	7½	A.C.
24″ x 24″ x 13′ 0″ Planer	7½	A.C.
24″ x 24″ x 13′ 0″ Planer	7½	A.C.
16″ x 4′ 0″ Engine Lathe	4	D.C.
36″ x 9′ 0″ Engine Lathe	14	D.C.
36″ Frame Slotter	20	A.C.
18″ x 6′ 0″ Engine Lathe	5	D.C.
600 Ton Wheel Press	15	A.C.
24″ x 5′ 6″ Engine Press	7½	D.C.
24″ Crank Shaper	3¼	D.C.
32″ Vertical Drill Press	2	A.C.
42″ Vertical Boring Mill	7½	D.C.
84″ Vertical Boring Mill		Belt
30″ Engine Lathe		Belt
No. 8 Floor Grinder	7½	A.C.
36″ x 44″ x 12′ Planer	15	D.C.
72″ x 84″ x 12′ Cyl. Planer	50	
	7½	
	5	A.C.
96″ Vertical Boring Mill	20	D.C.
5′ No. 2 Radial Drill Press		Belt
5′ Radial Drill Press		Belt
5′ Radial Drill Press		Belt
18″ Engine Lathe	5	D.C.
24″ Crank Shaper	3¼	D.C.
No. 4 Univ. Milling Machine	5	D.C.
No. 3 Milling Machine		Belt
No. 2 Reamer and Cutter		Belt
8 x 18″ Reamer and Cutter Grinder		Belt
Die Grinder		Belt
10″ Floor Grinder		Belt
38″ Vertical Boring Mill	10	D.C.
42″ Vertical Boring Mill	7½	D.C.
No. 3 Kuick Kut Hack Saw	3	A.C.
No. 8 Floor Grinder	7½	A.C.
16″ Engine Lathe	1	D.C.
16″ Engine Lathe	1	D.C.
16″ Engine Lathe	2	D.C.
20″ Vertical Drill Press	2	D.C.
6¼″ Turret Lathe	7½	D.C.

TIN SHOP TOOLS.

Description	H.P.	Drive
40″ Square Shear		
30″ Square Shear		
Cornice Brake		
Pipe Cutter		Belt

BOILER SHOP TOOLS.

Description	H.P.	Drive
A Plate Punch		
100 ton Hydraulic Riveter		
100 Ton Hydraulic Flanging Press		
4-Head Drill Press		Belt
Rivet Cutter	7.5	A.C.
No. 4 Shear	7.5	A.C.
No. A Plate Punch	7.5	A.C.
3′ Radial Drill Press		Belt
2″ Bolt Threader		Belt
No. 8 Floor Grinder	7.5	A.C.
Flue Welding Machine		Belt
No. 1 Plate Punch		
16″ Shear		
Flue Welder	7½	A.C.
Automatic Stay Bolt Cutter	13	A.C.
Plate Planer	10	A.C.
No. 3 Bevel Shears	10	A.C.
Horizontal Punch	7½	A.C.

TANK SHOP TOOLS.

Description	H.P.	Drive
No. 0 Roller	7½	A.C.
No. 2 Spacing Punch	7½	A.C.
No. 2 Shear	7½	A.C.
No. 2 Punch	7½	A.C.

WOOD WORKING MACHINE SHOP.

No. 3 Rip Saw	10	A.C.
4—74 Cut Off Saw	20	A.C.
Solid Frame Planer	5	A.C.
No. 70 Tennoring Machine	5	A.C.
Hollow Chisel Mortiser	5	A.C.
No. 214 Vertical Hollow Chisel Mortiser	20	A.C.
No. 4½ Smoothing Planer	20	A.C.
No. 58 Band Saw Scroll	5	A.C.

BLACKSMITH SHOP TOOLS.

Description	H.P.	Drive
No. 6000 Double Frame St. Hammer		
No. 3000 Single Frame St. Hammer		
No. 2000 Single Frame St. Hammer		
Description	**H.P.**	**Drive**
No. 616, No. 1800 Frame St. Hammer		
No. 1500 Single Frame St. Hammer		
4″ Forging Machine	25	A.C.
1½″ Forging Machine	7½	A.C.
2″ Forging Machine	15	A.C.
No. 300 Wooden Helm Hammer	25	A.C.
No. 2 Guillotine Bar Shear	7½	A.C.
No. 2 Guillotine Bar Shear	7½	A.C.
No. G. 18″ Throat Punch and Shear	10	A.C.
1½″ 4-head Bolt Cutter	5	A.C.
1½″ 4-head Bolt Cutter	5	A.C.
16″ High Duty Vertical Drill Press	8	A.C.
2-Head Sensitive Drill	2	A.C.
2-Head Sensitive Drill	2	A.C.
No. CM. Double Dry Grinder	5	A.C.
No. 10 Standard Blower	35	A.C.
No. 10 Special Blower	75	A.C.

COACH SHOP TOOLS.

Description	H.P.	Drive
No. CM. Double Dry Grinder	5	D.C.
50″ Wheel Lathe	50	D.C.
2 Singer Sewing Machines	2	D.C.
Hair Picker	2	D.C
Brass Buffer	4½	A.C.

WOOD WORKING MILL TOOLS.

Description	H.P.	Drive
No. 14 4-side Planer	50	A.C.
No. 281 Band Saw	15	A.C.
No. 457C Cut-off Saw	15	A.C.
No. 427 24″ Saw Self Feed Rip Saw	15	A.C.
No. 14, 4-Side Planer and Matcher	50	A.C.
No. 184, 12″ 4-Side Moulder	15	A.C.
No. 2 Small Cut-off Saw	10	A.C.
No. 330 5-Spindle Boring Machine	15	A.C.
Large Vertical Cut-off Saw	15	A.C.
No. 151 Car Tenoning Vertical Machine	10	A.C.
No. 7 Horizontal Hollow Chisel Mortiser	15	A.C.
No. 156 Double Surfacer	25	A.C.
Cabinet Makers' Saw	7½	A.C.
No. 58 Band Saw	3	A.C.
No. 5 Car Tenoning Machine	15	A.C.
No. 325, No. 1006, 3-Spindle Boring Machine	10	A.C.
No. 502 Gainer	15	A.C.
No. 576 Wood Marker	7½	A.C.
No. 58 Band Saw	3	A.C.
No. 238 Vertical Hollow Chisel Mortiser	15	A.C.
No. 177 Double Surfacer	25	A.C.
No. 5 Cut-off Saw and Dado Machine	5	A.C.
No. 115 Self Feed Rip Saw	7½	A.C.
No. 181, 8″ Moulder	10	A.C.
No. 531 Cabinet Tenoning Machine	5	A.C.
No. 201 Shaper	7½	A.C.
No. 478 Universal Saw Bench	5	A.C.
No. 205 Hollow Chisel Mortiser	3	A.C.
No. 199 Hand Planer and Gainer	7½	A.C.
No. 50 Band Saw	3	A.C.
No. 8 Universal Hand Trimmer		
No. 8 Universal Hand Trimmer		
No. 601 Sash and Door Clamp		
No. 253 Knife Grinder		
Saw Grinder		
Foley Band Saw Filing and Joining Machine		
No. 207 Hollow Chisel Mortiser	5	A.C.

WHEEL SHOP TOOLS.

Description	H.P.	Drive
42" Vertical Car Wheel Borer	20	D.C.
42" Vertical Car Wheel Borer	10	D.C.
150 Ton Wheel Press	7½	D.C.
Double Head Axle Lathe	25	D.C.
24" Scepto Lathe		
CM. Emery Dry Grinder	4	D.C.
Double Head Axle Lathe	10	D.C.
400 Ton Wheel Press	11½	D.C.
8-Spindle Angle Cock Grinder		Air
Triple Valve Test Cock		

Lesson No. V.

The Lead Storage Battery.

CLEANING.

(Continued from last month.)

Cadmium Test.

When trouble is found in any cell especially that of loss in capacity, it is very necessary to know whether the trouble is due to the positive or negative plates. By placing a small stick of cadmium in the electrolyte and reading the voltage to both the positive and negative plates, the voltage delivered by each cell may be divided into two parts.

(*a.*) That furnished by the positive plate.

(*b.*) That furnished by the negative plate.

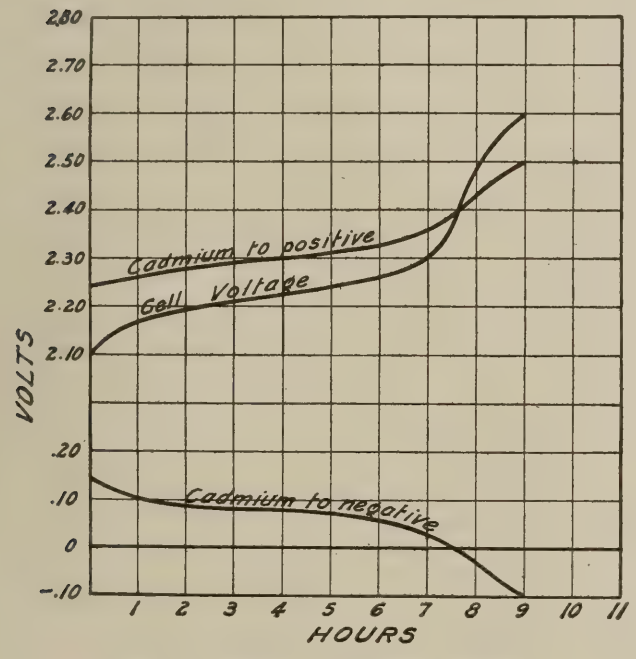


Fig. 21. Cadmium Test Voltage Reading.

The cadmium test piece should be free from all impurities and its surface should be scraped bright, but after that it should be aged to a grayish color, i. e. left in the acid until covered with a thin layer cadmium sulphate.

This little test piece, usually 2 or 3" long, should be covered with a rubber tube having holes cut in it so as to allow the electrolyte to come in contact with the cadmium. This rubber tube will then insulate the cadmium and prevent it touching either of the plates. Should this occur it would cause a direct short circuit between the cadmium and the plate touched.

Charge.

At the beginning of charge with plates in a discharged condition, voltage of cadmium to negative will be about + .15 volts, the cadmium to the positive + 2.25 volts,

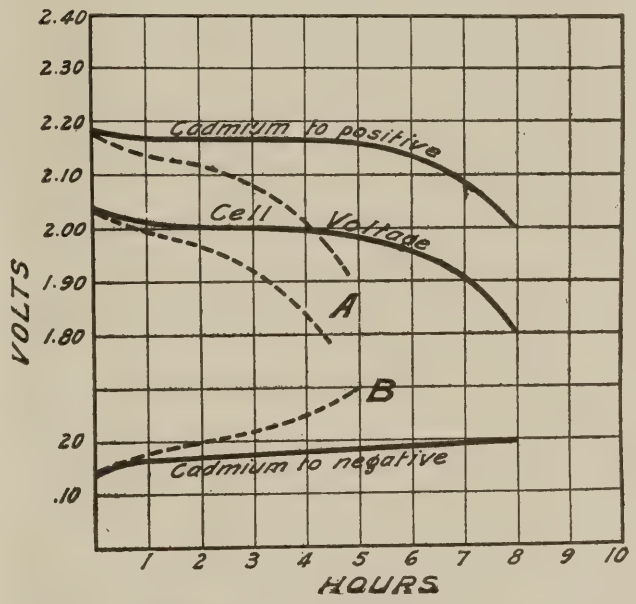


Fig. 22. Cadmium Test Voltage Readings Showing Trouble.

the voltage from positive to negative plates being the difference between the two or 2.10 as shown in Fig. 21. As the charge proceeds the cadmium to negative will gradually fall off while the cadmium to positive rises. The cell voltage which is the difference between the two will rise even faster than the cadmium to positive will. At the point near the completion of charge the cadmium to negative voltage will fall to 0, and at this point the voltage of the cell is just equal to the cadmium to positive voltage. As the charge is continued further, the cadmium to negative voltage will be reversed, and the cell voltage line will cross the cadmium to positive line for the cell voltage is then the sum of the cadium to positive and the cadmium to negative readings.

In actual practice it is sometimes difficult to make these readings check exactly on account of the small reading given between cadmium and negative plates and also on account of variation in location and condition of the cadmium test piece.

Discharge.

At the beginning of discharge, the cadmium to negative reading should give about .15 volt, and the cadmium to positive about 2.19 volts, while the cell voltage is the

difference between the two or 2.04. A slight difference in temperature or density of electrolyte will alter these readings slightly however. As discharge proceeds, the cadmium to negative slowly rises to .20 volts as shown on Fig. 22, while the cadmium to positive falls practically parallel to the cell voltage curve.

Low Capacity in Positives.

If the cadmium to positive cell voltage readings are found to fall off rapidly as shown by the dotted curve "A" Fig. 22, while the cadmium to negative follows normal curve, you may be sure that the positive plates are low in capacity. Battery should be recharged and a second test made, first making sure that the battery is fully charged. If indications of sulphated positives are shown, give the battery "Treatment for Sulphated Plates" and make a new test. If the positive to cadmium voltage again falls off rapidly as shown in dotted curve "A," the plates may have to be renewed if its capacity is not sufficient for the requirements of the service.

Low Capacity in Negative.

If the cell voltage at the end of 5 hours drops to 1.8 and the cadmium to negative has risen to .30 volts as shown on dotted curve "B," while the cadmium to positive voltage holds up to normal value, it indicates that the trouble is in the negative plates and that they are lacking in capacity. This is usually due to hardening of the negatives and should be given treatment as given under "Hardening of Negatives" *(May lesson)*.

TROUBLES TO LOOK OUT FOR.

1. On charge be sure battery is connected in the right direction. Positive of battery to positive of charging source, etc.
2. Never let the battery discharge below 1.75 volts per cell. This is equal to 28 volts for 16 cells, (32 volt system), 56 volts for 32 cells (64 volt system) and 94 volts for 54 cells (110 volt system). At this point the battery capacity is gone and if you allow battery to discharge further it will seriously injure the plates.
3. Never let the battery get too warm, 110° *F is the danger point.* If charging a battery and the temperature reaches this point stop charging until the battery cools off.
4. Don't let the battery stand in a completely discharged condition, nor even in a partly discharged condition for more than a few hours.
5. Never let the level of the electrolyte get below the tops of the plates. This will badly sulphate the exposed parts.
6. Never use acid to flush the cell with. Use only distilled water or water approved for this purpose.
7. Don't overcharge the battery for more than ½ hour except on monthly overcharge or in cleaning battery.
8. Be careful that the gravity of the acid never goes above 1.230. This is the danger point. Acid stronger than this will sulphate the plates.
9. Never allow the sediment in the bottom of the tanks to get so deep that it touches the cells. This is usually the cause of short circuited cells.
10. Never allow a short circuited cell to remain short circuited. Take it out of the battery and remove the short circuit. If it is caused by deep sediment you will undoubtedly find that the whole battery needs cleaning.
11. Watch out for loose connectors. They may cause battery circuit to open, resulting in the failure of the equipment.
12. If the connectors become corroded wipe them off immediately for if the copper sulphate formed, is allowed to get into the battery it will ruin the plates. Try and cover the corroded part of the connector with vaseline.
13. Never bring an open flame near a battery. This may cause a violent explosion of the gas given off by the battery.
14. When cleaning the battery be sure to fully charge it before removing the plates from the cells.
15. When you have taken the negatives out of the tanks in cleaning be very careful they do not become dry. They should be immersed in acid or water as much as possible during cleaning operation.
16. Watch out for grounds both in the battery and in the car wiring. To detect these see "Grounds." Grounds in the battery circuit will rapidly discharge the battery and should be immediately removed.
17. In reading battery voltage be sure and have all lights on for a few minutes before taking the reading. An open circuit reading of battery voltage means absolutely nothing, a battery even completely discharged may give reasonably high open circuit voltage.

DEFINITIONS.

Active Material—The peroxide of lead and the lead sponge are the active part of the plates.

Ampere Hour—The measure of size of a battery: 1 ampere hours means 1 ampere flowing for 1 hour, 20 ampere hours may mean 20 amperes for 1 hour, 10 amperes for 2 hours, or 5 amperes for 4 hours, etc.

Bottom Rests—The porcelain or hard rubber ribs on which the elements rest.

Buckling—The warping of the plates out of shape due to swelling up of the active material.

Buffers—The porcelain blocks placed on the four sides of the tank to insulate it from battery box.

Bushings—The molded soft rubber parts placed around the battery terminal posts.

Capacity—The size of the battery which is expressed in ampere hours. This is generally taken at the 8 hour rate.

Conectors—The rubber or lead current wire used in connecting the positive and negatives posts of adjoining cells.

Compound—The sealing compound used to flood the top of the cell after covers have been placed in position.

Crate—Double compartment wooden tank in which the elements are placed.

Electrolyte—Mixture of sulphuric acid and water in which the plates are placed. Normal electrolyte is 1.220 specific gravity.

Elements—the positive and negative plates of the cell assembled with separators.

Electro Motive Force—This is a name often applied to the voltage of a storage cell when on open circuit.

Group of Plates—The several positives or negatives and the bridge or cross strap to which they are burned.

Negative Plate—The spongy lead plate or group of plates. These are of a slate gray color.

Positive Plate—The plate or group of plates which are of a chocolate brown color.

Reserve Lead—In Plante or formed type plates, the active material extends only for a short depth over the surface of the webs. The unattacked lead in the center of the webs which is later gradually converted into

active material as the battery grows older is known as reserve lead.

Rollers—the porcelain or other molded insulation which acts as rollers under the battery so that it may be more easily handled.

Rubber Linings—The insulated material placed between the element and the lead lining of the tank.

Sediment—The collection of active material in the bottom of the tanks. This looks like mud.

Separators—The insulating material usually wood or a sheet of perforated hard rubber placed between positive and negative plates.

Short Circuit—Any metalic or conducting material which bridges the gap between plates or wire and permits current to flow either through one individual cell or the whole battery.

Specific Gravity—The weight of the electrolyte as compared with any known volume of water at a temperature of 62° F. Normal gravity of 1.220 means that it is a trifle over 1.2 times as heavy as pure water.

Vent Plug—Small hard rubber plug screwed into the cover. This permits gas forming on charge to get out of the cell.

Skids—Porcelain blocks screwed on the bottom of tanks which act both as insulators and shoes to slide the twin cell around on.

QUESTIONS AND ANSWERS.

1. *Q.* Level of the acid in the battery goes down so low that the plates are exposed. What shall I do?

Answer. You never should have let the electrolyte get so low, it ruins the plates. Add enough pure water (preferably distilled) to cover the plates about 1¼". Measure this with a little clean stick of wood; don't use your brass rule.

2. *Q.* Battery was so hot this morning when I finished my run that I could hardly bear to touch it. Will this hurt the battery?

Answer. I should say so—it is about the worst thing you could do to that battery. It was undoubtedly the cause of too much overcharging or charging at too high rate. Overcharging at high temperature will ruin the battery quicker than anything else.

3. *Q.* Gravity of pilot cell and other cells in battery falls below 1.170 at the end of charge and overcharging does not bring is back to normal. What's the matter?

Answer. Look at the plates and if the positive has a grayish color instead of a rich chocolate brown and the negative is rather white instead of lead gray, the plates are sulphated and should be given a few heavy overcharges to break up the sulphate. If this is not sufficient try the alkali treatment given on page ———.

If the plates are of good color you will probably find a heavy deposit of sediment in the bottom of the cell. Cells should be cleaned if this is more than ½" deep.

4. *Q.* A pilot cell gravity up to 1.220 at the end of charge O. K. but voltage on discharge soon falls below normal. What is the trouble.

Answer. You will undoubtedly find that there are one or two cells which give a lower voltage reading than the rest (all lights on). Take these cells out and examine them carefully; you will prabably find them in a sulphated condition due to some local action possibly an impurity in the electrolyte, iron or copper, or there may be a direct short circuit between the plates possibly caused by deep sediment in the bottom of the cell. Take these cells out of the battery and put good cells in their place, then remove electrolyte from the cells in trouble, replacing it with new electrolyte and give a number of overcharges to break down the sulphate. Watch the gravity closely so that it does not go over 1.225, if so, dilute with pure water. If this treatment fails give the plates one charge in alkali as given on page 290, (May lesson.)

5. *Q.* I have light failures when the battery is discharged for even a half hour, yet I know battery has been given complete charge every day for months. How do you explain it?

Answer. You have probably given your battery altogether too much overcharge possibly at high temperatures so that the active material has been boiled right out of the plates. This leaves only a very small amount of material available for discharge. It may, however, be due to individual cell troubles as in question 4.

Practical Stunts

SOME AXLE LIGHTING TROUBLES AND HOW TO TAKE CARE OF THEM.

(A talk given before the May meeting of the Car Lighting Club, by H. G. Meyers.)

As you all know, the successful operation of any equipment depends on its weakest parts, and the inspector by becoming familiar with the weak parts, may anticipate many of the troubles and make repairs before a failure occurs, such as, corroded battery connectors, loose wires on the dynamo, regulator, or switch board, flexible dynamo leads that are almost broken and hanging by a few strands, back dynamo brushes that are gummy and do not move freely, link fuses not screwed down tight, belts that are cracked too deep at the clamps to be safe. These items come under the head of careful inspection. The equipment would respond to the usual tests in the yard, but would probably fail on the road.

On the other hand there are troubles that may not be anticipated, and we have all had the experience of theorizing on a case of trouble which turned out to be something different. I had one case of this kind last winter, the regulator inspector reported a car in which the locker lights would burn, but when the car load was applied the lamps would go out, I felt safe in assuming that the solution was out of one cell of battery, and that the wet separators would convey enough current for the locker lamps, but not enough for the full load. The trouble turned out to be a battery wire broken in the insulation and corroded, this wire tested continuous with the buzzer, and the only way we could locate the bad wire was with a temporary battery wire.

Then we have troubles that test out O. K. in the yard but persist in occurring on the road. We had a case of this kind recently, one of our café cars was burning out dynamo fuses occasionally without any apparent reason. The equipment was gone over thoroughly and no trouble found. It was necessary to ride the car to find the trouble, which was found to be a small piece of copper that had fallen in the tripple contact of the automatic switch. The copper would dance around with the motion of the car and short circuit the field resistance, which would cause an enormous current to flow.

We had a case of trouble with the bell wiring in a Buffet car which it seemed impossible to locate for a while. The trouble first developed in three circuits and, as the bell wiring is usually hard to get at and the time was short, the three circuits were cut out. On the next trip of the car the balance of the circuits were bad, we naturally thought of a nail being driven into the cable at some point, but none were found. We found a clew, however, when the upper berth was pulled down, the side of the car was very damp. This was so unusual that the matter was reported to the car foreman, who found a leak in the hot water box under the car, which permitted enough steam to come up between the sidings

to wet the bell cable. The cable dried out in one trip after the leak was repaired.

Almost any business has its troubles and it is only by systematizing and proper records that they can be controled. With your permission I will outline the system in use at the Santa Fé yards.

An inspector meets the trains as they come in, feels the regulators to determine whether the equipment has been working, and makes such other examination as time will permit. Should there be a failure or a doubtful case the inspector notes it on a blackboard placed in the shop where all can see it. In the meantime the gravity inspector is getting the acid readings, and any low readings are noted, the results of these two inspections check with but few exceptions.

An equipment may be aparently O. K., but the acid may be down 25°. This may be due to several causes, such as, burning lamps unnecessarily, a failure on the road that has been repaired, or a ground which diverts part of the useful current. In any event, when the car reads low the battery is charged. One side of our charging line is grounded, both ends of the battery is flashed with the live wire to test for grounds. This test is of great assistance and has saved many a failure. Another "Ounce of prevention" is the motoring of equipments, you would be surprised to know how much trouble we find by using this test.

The subject of different oiling devices have been discussed often, and at the present time there is in use among the different roads the ring, chain, and wick oiler, and the packed bearing. The pulley end of the dynamo is the dynamo inspectors greatest trial, chiefly on account of the time it requires to change bearings and also because the armature shafts wear most at this end. We have all of the above oiling devices in service, and so far the packed bearing has given us the longest bearing life. I attribute this success to the fact that no grit or dirt can get in the bearing to cut in out. Bysimply comparing the results I am led to believe that if the pulley end head could be closed so that dust could not sift in and mix with the oil, we would have the same good results with the other oiling devices as we do with the packed bearing.

As a further proof of the dirty oil theory I will state that we are using wicks on the commutator end with entire satisfaction. We do not approve of the wick, however, on account of the risk in connection with its use.

Long belt life depends in a great measure upon perfect alignment, careful inspection both as to the clamps and the cracking at the clamps, and the continued use of crowned dynamo pulleys. The crowned pulley keeps the belt from rubbing on the flanges; we all know how destructive this is to the belt.

The old pressed steel axle pulley is fast disappearing, this pulley would not stand the frequent removals and re-applications and in time the rim would become warped out of true. We have traced a number of lost belts to these uneven pulleys. The pressed steel pulley of today is made to last, and we have had no trouble with them. For our own cars we use a malleable cast pulley that is no heavier than a pressed steel pulley of the same size. A bushing is not necessary, as the taper is cut in the hub of the pulley.—H. G. Meyers, Elec. Fm'n. Santa Fe.

POSITION WANTED.

Nine years experience as electrician with head-end systems in limited trains with some general experience in building and car wiring and with axle devices. Wish to make a change on account of personal reasons.

Address,

A. B. M. RAILWAY ELECTRICAL ENGINEER,
106 N. La Salle St., Chicago, Ill.

How Car Lighting Batteries are Made.

The tanks usually furnished are of the compartment type, and are made of kiln-dried white oak. All the joints are dove-tailed through and are dowelled in both directions. The screws are resined and countersunk and the holes filled with wood plugs glued in to protect the screws. Porcelain buffers on the sides and ends insulate the tanks from the battery compartment and from each other. Porcelain skids or rollers are secured to the bottoms of the tanks.

Lead tanks or rubber jars are placed inside the wood compartments and the interstices for which allowance has been made are filled with insulating compound. The insides of the wood compartments and the outsides of the lead tanks are properly treated with 3 coats of acid proof paint. The insides of the lead tanks are insulated from the elements by hard rubber sheets. The elements are supported by bridges in the rubber jars, and in the lead tanks by two porcelain or glass rests held in place by lead retainers.

The covers both for the lead tanks and for the rubber jars are made of hard rubber and are so shaped as to allow of proper sealing with battery compound. The holes through which the pillars pass are fitted with soft rubber bushings and vent plugs fitted into threaded holes in the covers and also provided. The tops of the pillar posts are properly marked Positive (X) and Negative (—).

The intercell connectors are copper cable covered with pure rubber insulation. Bolt connectors secure the cable connectors to the pillars. The two end terminals are either lead covered with studded bolts or have ferrules for burned in connectors or standard hand connectors, and are connected to the fixed battery leads. Where the lead covered terminals are used a proper lead covered nut is furnished.

GOULD CAR LIGHTING BATTERY.

In the Gould Car Lighting Battery both positive and negative plates are of the Plante type. The "spinning" process is used in the manufacture of these plates giving a greatly increased surface and modification in form of

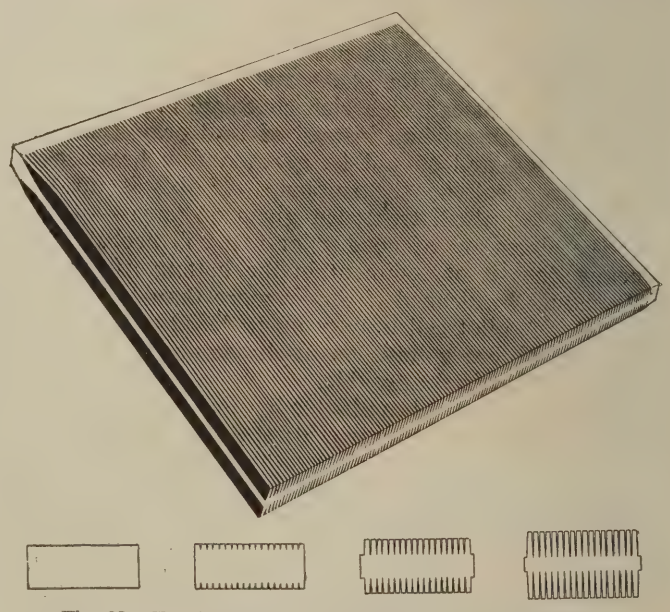


Fig. 23. Showing Method of Manufacture of Gould Plate.

rib and groove. The plate with lug is stamped as a blank sheet from chemically pure rolled lead. It is then placed in a steel frame which reciprocates back and forth between two revolving mandrels on which thin circular steel discs and spacing washers are mounted.

The thickness and form of the revolving discs determines the width and shape of the groove between ribs, and the thickness of the washers, the thickness of the ribs. The travel of the frame back and forth determines the length of the section to be spun, but in plates for car lighting work this extends over the entire length of the plate, leaving just enough unspun material at the edges to form a substantial support and conducting frame.

As the blank plate moves back and forth between the spinning rolls a uniform pressure of the revolving discs is maintained against the surface of the lead blank by means of compressed air. Ridges and grooves begin to appear as soon as the operation is started and as the "spinning" discs sink further and further into the lead, as shown in the accompanying illustration, the lead of the blank is slowly formed into thin ribs which fill the spaces between revolving discs. No lead is removed, the blank is merely changed in form. There is no cutting or bending of the lead which would open the pores or cause crystalization, it is squeezed and drawn into shape.

By limiting the depth that the discs penetrate the blank a relatively heavy weight of metal remains as a support for the ribs and a central conductor for current.

On the greatly increased surface of the ribs thus produced a thin layer of lead oxide or "active material" is formed electrolytically.

Negatives are made from positives thus formed, by a subsequent conversion of the lead peroxide to spongy lead by charging as negatives. The plates are finally

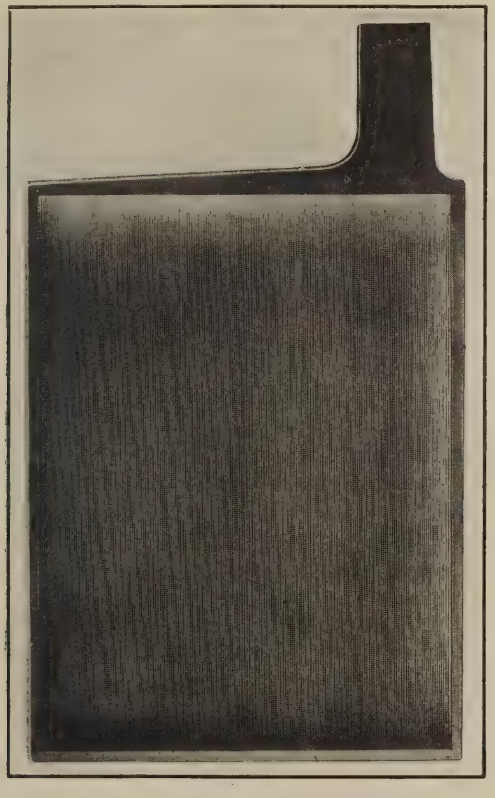


Fig. 24. Gould Car Lighting Plate.

subjected to a purification process to remove any impurities which may have been acquired during the process.

SALOM STORAGE BATTERY.

The Salom storage battery, which has been placed on the market within the last two or three years, differs in many respects from both the Plante and pasted type of battery.

The process of manufacture is novel and interesting, inasmuch as the active material (peroxide and spongy lead) is produced in its final condition in bulk and then applied to the antimonial supporting grid, thus producing the initially formed plate. This method of manufacture does away with the formation process of the plates in the factory and enables them to be assembled as soon as they are manufactured.

Spongy lead produced electrolytically and therefore chemically pure is put into the negative grid under extremely high pressure. It is claimed that this pressure is sufficient to cold weld the spongy lead and grid into a porous sheet. Applying the material under pressure in this way insures a perfect contact between the active material and the grid, and there being nothing in the active material but pure spongy lead when applied, there is no chance of shrinkage with a resulting loss in capacity.

The positive plate is made in a similar way, taking peroxide formed electrolytically in bulk and having mixed with it a binder before it is applied to the grid under pressure. This binder acts as a cement just the same as Portland cement does in concrete, hardening up all the active material and giving it great mechanical strength.

One of the claims is, that owing to the fact of the binder being thoroughly and evenly mixed with peroxide before it is applied to the grid under pressure insures a uniformity of the active material and close contact with the grid which cannot be obtained by any other method of manufacture. Unless the positive plate is seriously overcharged, the binder should remain in its original inert condition and prevent the peroxide from softening up and disintegrating.

Owing to the purity of the active material and the excellent contact between it and the grid it is claimed that a higher discharge voltage is obtained than ordinarily. The manufacturers say that 20 per cent more active material can be placed in the grid, due to the pressure under which it is applied. This gives a greater capacity for a given weight.

The above features of superiority which are claimed for this battery make its further development a matter of interest to all railway engineers interested in the application of storage batteries to their service.

"U. S. L." CAR LIGHTING BATTERY.

In the "National" battery both positives and negatives are the Plante type made from single blanks of dense chemically pure rolled lead. The leaves or ribs of the plate are formed by the rocking action of sets of knives which slowly force their way into the body of the blank plate and work it up into the many leaves required to give the plate surface. These leaves are formed entirely by displacement of the lead in the blank, no material whatsoever being cut away.

The plates vary in thickness with different specifications. The negative plate is always somewhat thinner than the positive plate, as the service requirements are less severe. To secure the maximum surface, and therefore capacity, the leaves in the positive plates are continuous from top to bottom. The negative plates however are of the four biscuit type with a horizontal and vertical rib running through the center of the plates.

The last mentioned type, C. L. F., pasted plates give approximately twice the capacity of the Plante type of an equal size and weight.

Rubber and wood separators together or rubber alone are used according to specifications. The flat wood separators are inserted between the rubber separators and the negative plates.

WILLARD TRAIN LIGHTING BATTERY.

The conditions under which a train lighting battery is operated are so entirely different from any other class of battery service that it was very early found necessary to develop a battery especially designed for railway train lighting. The present Willard train lighting battery has been developed with all the special requirements in view and to meet the varied conditions of service with minimum maintenance cost.

The plates are essentially the same as in the first train lighting batteries manufactured by the Willard Company; but with improvements in details worked out from experience gained in actual service.

Both the positive and the negative plates in the Willard train lighting battery are of the Plante type. The positive plate is made from rolled chemical lead weighing 17 lbs. per square foot. The surface of the lead blank is developed so that the active area of the plate is ten times the superficial area of the plate.

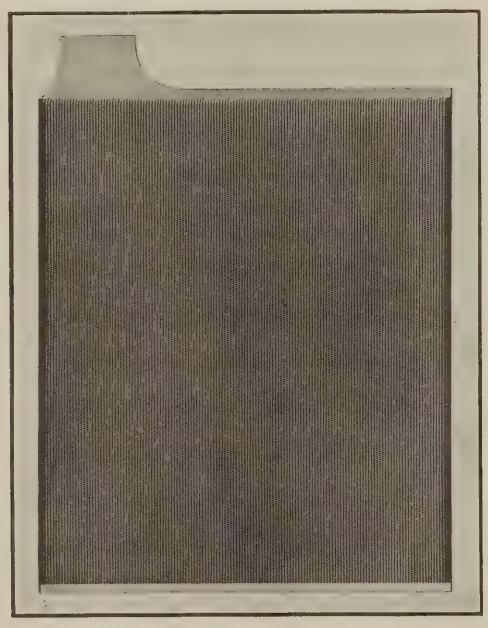


Fig. 25. View of Willard Plate.

This is done by raising ribs from the sheet itself and without disturbing the structure of the original sheet of lead. These ribs are produced one at a time by means of a rigid tool placed in a special machine made for this purpose. As shown in Fig. 1, these ribs take up the entire surface of the plate, leaving no blank spaces, but making the total surface of the plate active.

By using a rigid tool, it is possible to get ribs of the utmost uniformity. The maximum variation in the thickness of these ribs is only 2-1000". By shaping the tool, the rib can be given any shape and thickness desired.

In the positive plates, the ribs are tapering from the root towards the top, i. e., they are thicker at the base and gradually get thinner towards the outside of the plate. This gives a "V" shaped groove for the active material. It also increases the lasting quality of the ribs.

The plate is provided with a center web which is 1-16" thick at the bottom of the plate and gradually tapering toward the top. This allows an even current distribution. In determining this center web, the same principle is used as when determining the copper conductors of a distributing system for current. The center web is made substantial to eliminate expansion and buckling of the plates.

The ribs and the spaces in the positive plates are so proportioned that the battery will give its rated capacity and still give a maximum amount of lead in the ribs. This lead is utilized later on in service and determines the life of the plate.

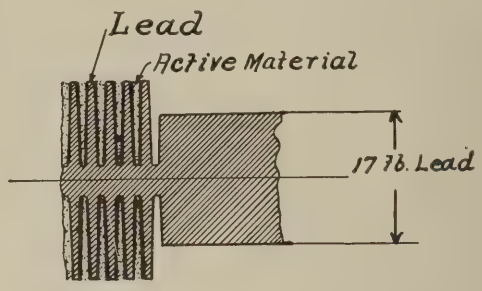


Diagram of Positive Plate

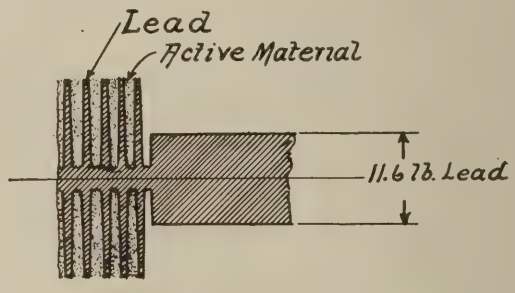


Diagram of Negative Plate

Fig. 26. Illustrating Method of Manufacture of Willard Plate.

The object of developing the entire surface of the plate and not leaving any exposed blank spaces is to distribute the electro-chemical action uniformly over the entire surface of the plate, thereby eliminating the tendency to buckle.

In raising the ribs, they are given a slight angle in relation to the center web. After the battery is placed in service and the active material expands, the ribs raise up perpendicular to the center web, thereby increasing the space taken up by the active material, eliminating expansion of the plate horizontally.

The positive plate is made ¾" to 1" shorter than the negative plate, thereby allowing for vertical expansion, which takes place under especially severe service conditions.

The negative plate is also made of rolled chemical lead and the surface developed in practically the same manner as on the positive plate. The active surface is developed to ten times the superficial area of the plate.

The negative plate is made from lead weighing 11.6 lbs. per square foot and will, therefore, after the surface is developed give a plate in which the ribs are thin and the spaces for the active material very wide in comparison to the spaces in the positive plate.

The negative plate is also provided with a center web; but thinner than the web in the positive plate and only intended to give the plate sufficient strength.

Fig. 2 shows a diagram of the relation between the ribs and spaces in the positive and the negative plates.

In the negative plate a big bulk of active material is required, and the plate is so constructed that the capacity of the negative plate when new will give approximately twice as much capacity as the positive. This allows for shrinkage in the active material in service

and assures a negative plate that will give its full rated capacity until worn out.

Both the positive and the negative plates are electro-chemically formed, i. e., the active material in the plates is applied electro-chemically.

The developed plates are immersed in a solution between lead dummies. This solution consists of electrolyte of the proper density and a certain percentage of a forming medium, whereby is understood an acid or a salt that will attack the lead. Current of the proper density for a plate is forced through the plates. The combined action of the current, the forming medium and the electrolyte tends to oxidize the plates filling the grooves between the ribs with peroxide of lead or positive active material. The negative plates are put through the same process of oxidizing; but are afterwards reversed, changing the peroxide of lead to spongy lead or negative active material.

The above process which is called the forming of the plates is of great importance, as it determines to a great extent the initial capacity as well as the life of the plates.

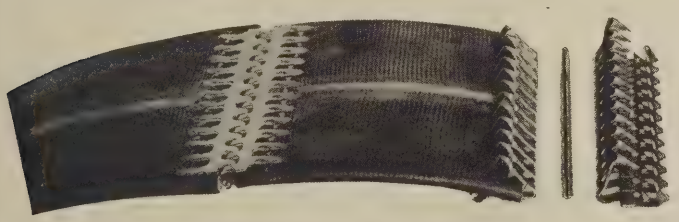
In the construction of the details of the battery, there has been a tendency in the last few years to standardize on certain sizes and certain details in construction, such as rubber separators, lead lined wooden tanks, hard rubber covers, etc., and in the building of the Willard train lighting battery, the elements consisting of the positive and negative plates are assembled, in these standard containers, charged and sealed ready for service before being shipped out.

(Car Lighting Lessons to be Continued.)

FLEXIBLE STEEL LACING.

It is a well experienced fact that only 25% or less of the belts operated in car lighting service are actually worn out. 75% are either torn apart at the belt fastener or cut to pieces by riding the pully flanges. Undoubtedly a large number of these that are lost are due to belt fastener troubles.

Accordingly the new belt fastener known as the "Alligator" fastener, and manufactured by the Flexible Steel Lacing Co., of Chicago, is of special interest to all



Flexible Steel Lacing.

car lighting men. The fastener itself and its method of application are clearly shown in the accompanying illustrations.

The fastener is designed to give a maximum holding power and a minimum cutting of belt fiber. A rocker hinge pin as shown above is provided with a corrugated surface to prevent the pin from slipping out while in service.

This pin is made up of two parts which as the belt engages a pulley, simply rock on each other. There is no friction or sliding of the fastener loops over the pin, hence there is very little wear, if any, in operating this fastener even in the most severe conditions of service such as found in railway car lighting. The corrugations on the back of the rocker pins prevent the pins from slipping out while in use, and even in case one of the pins may be broken in heavy service, the strength of the fastener will not be important.

As the fastener engages both sides of the belt alike, the strain is thrown in a direct line of pull, thereby eliminating bending effect of any one side fastener.

Rocker Hinge Pin.

The teeth on each side of the lacing enter the belt on different lines of perforation; each prong has two teeth, the longer clinching through the belt while the shorter on the opposite side of the prong gives an added strength. These teeth are bent in manufacture so that when they are in operation the pull is against the edge of the teeth instead of the sides. This gives a much stronger tooth and at the same time does not weaken the belt like the side pressure tooth would.

One of the features of this fastener which adapt it particularly to car lighting service is that the belts may all be cut to a standard length and the fasteners carefully applied to each end of the belt in the shop, where, with a convenient place to work, a very careful job can easily be made.

To place this belt on a generator, it is then only necessary to let out the takeup screws of the generator, throw the belt over the axle and armature pulleys, bring the ends together, insert the rocker hinge pin and tighten.

This is a matter of about 3 minutes work from start to finish and a perfect job is always made since the real work of applying the fastener has been carefully done in the shop some time previously.

As to the strength of this fastener, many practical tests have shown a 4 in. belt fastener applied to a 4 in. 4 ply, stitched canvass belt to stand a total pull of 3360 lbs. before breaking. A test of a 4" extra heavy single leather belt shows a fastener strength of 3248 lbs.

WESTINGHOUSE D. C. TURBO GENERATORS.

Westinghouse type T, direct-current, turbo generator units find wide application where a simple, compact, reliable generating set is desired. Many are used for exciter sets in alternating-current generating stations, for lighting and power in industrial plants and in office and apartment buildings, for storage battery charging in railway signal work, and for train lighting They are particularly applicable for exciter service in modern generating stations where the steam pressure exceeds 125 lbs. per square inch because small reciprocating engines ordinarily used for driving exciters are usually designed for pressures not greater than 125 lbs. per square inch. Where the boiler pressure exceeds 125 lbs. per square inch, a reducing valve must be used with such engines. Type T turbines operate directly on pressures up to 200 lbs. and with steam superheated to 150 degrees Fahrenheit.

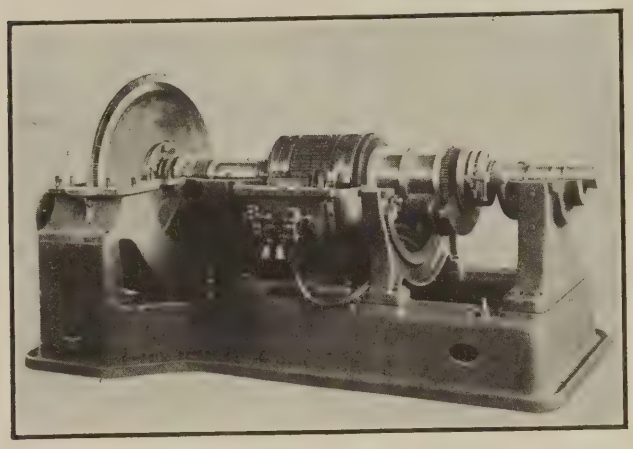
As compared with reciprocating engine sets the features in favor of the Westinghouse turbo-generator set are:

Simplicity—Reliability.—There are few moving parts such as rods, levers, eccentrics, and cranks. There are few parts that require attention because of wear, there are very few bearings to oil, and no stuffing boxes to pack. There are no reciprocating parts to wear out and no steam cylinders to be oiled.

Compactness.—A reciprocating engine set occupies from one-half again to several times as much (depending on the speed and other characteristics) space as does a turbo-generator set.

Lower Cost of Installation.—The first cost and the

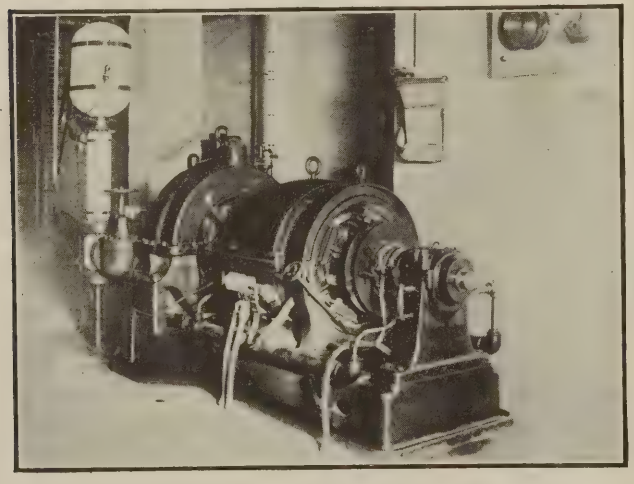
installation cost are less for a turbo set than for an equivalent reciprocating engine set. Expensive foundations are not required for a turbo-generator unit.



Westinghouse Turbo Generator Set.

The line of type T sets includes machines of the capacities most in demand of from 10 kw. to 200 kw. Standard voltages are 125 and 250. Three-wire generators—125 and 250 volts can be supplied. The steam pressure range is from 75 to 200 lbs. per square inch. Either shunt or compound wound generators can be furnished. Standard compounding is 118 volts, no load, and 125 volts, full load or 235 no load, and 250 full load. Compounding can be varied by adusting the shunt.

The turbine is of the single wheel impulse type. The wheel or rotor is mounted directly on the end of the generator shaft. Although only one impulse wheel is used an unusually high efficiency is obtained by using steam two or more times on the one wheel. The governor is of the fly-ball type. The weights are hung on hardened steel knife edges, minimizing friction. In case of over-speeding, the automatic safety-stop throttle valve is tripped, shutting off the steam supply.



Turbo Generator Set Dismantled.

Type T generators are of the commutating type which insures sparkless commutation with a fixed brush position at all loads within the capacities of the machines.

Frames are of cast iron. Bolts hold the pole pieces to the frames. All frames are divided horizontally. Main poles are built up of soft sheet steel punchings. The use of bolted-on poles permits of uniform pole spacing and in addition renders possible the removal of any individual pole. Commutating poles are of steel and are secured to the frame with bolts. Main field coils may be either shunt or compound wound. Shunt coils are wound on forms and provide a large radiating surface. Series coils are wound of bare copper bar. The best possible heat radiation is assured.

The commutating pole coils are wound of bare copper bar held in position with insulated bolts. The ventilation is thorough. Brushholders are mounted on rigid arms and the brush tension can readily be adjusted to keep it uniform as the brush wears away. Armatures are of the drum type. Armature coils are form wound, interchangeable, and thoroughly insulated. The spaces between the coils at the ends of the armature are packed with insulating material to prevent the entrance of dirt. Commutators consists of hard drawn copper bars insulated with mica. Steel rings shrunk around the bars but insulated therefrom prevent distortion by centrifugal stresses.

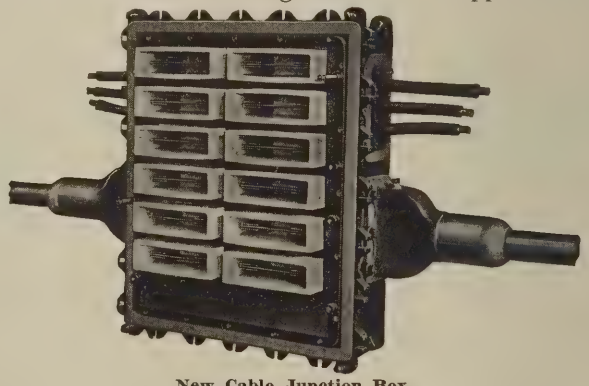
A complete oiling system of the type best adapted to the service is provided with each turbine. In the smaller sizes the well-known ring oiling scheme is employed. In the larger turbines the oil is circulated through a closed system, by means of a rotary pump driven by the main shaft through positive gearing.

All parts of the turbine are readily accessible for inspection or repair. The upper half of the cylinder or casing may be removed without interfering with the valve or governor mechanism, and, if necessary, the wheel or rotor may be entirely removed from the casing.

Generally speaking, the steam consumption of turbines of small powers compares favorably with the performance of automatic high speed engines of similar capacity. As Westinghouse turbines are carefully tested in the shop before shipment, there can be no uncertainty as to their performance. The guarantees of steam consumption are based on an average of actual test results, plus a comfortable margin.

A NEW CABLE JUNCTION BOX FOR HIGH TENSION TRANSMISSION CIRCUITS.

A new type of cable junction box suitable for the inter-connection of high voltage feeders and mains is shown in the accompanying inllustration. This is the first high voltage junction box made in this country, we believe. It will be noted that the flexible leads which project through the sides of the box are so arranged as to terminate within the large removable nipple. These



New Cable Junction Box.

nipples have a rounded or dome-shaped end made entirely of soft metal such as lead or lead-tin alloy. This dome-shaped portion is united with that portion of the nipple which is of brass or other rigid material by an exceedingly strong and absolutely water tight joint. The leads are connected to the outermost contact points of each row of disconnecting switches, the innermost point being connected to bus-bars, giving the desired interconnecting arrangements.

The exposed live parts—that is, those shown in the cut, are isolated in cells of porcelain so that the disconnecting blades can be inserted or removed perma-

nently fastened in a metal framework which, in turn, is fastened to the box, in such a manner that a chamber is formed between the framework of cells and the bottom and sides of the box.

This chamber, after the carrying parts that enter it are put in place and insulated with tape, when desired, and after the moisture has been removed by the heat and vacuum process, is filled with a hot insulating compound. Insulating stuffing boxes prevent the compound from oozing out along the flexible leads when the box again warms up under working load. The concealed current carrying parts of this box are, therefore, assembled and insulated before the box is sent out from the factory, where the work can be done with the greatest care by operators skilled in that particular work under expert supervision.

In order to make the cable connections, all that is necessary, is to unbolt the nipple from the box, cut off, with a saw or jack knife, the dome-shaped end of the soft metal portion of the nipple and, after threading it over the table, joint the conductors to the insulated flexible lead. After this the nipple can be replaced, the joint wiped and the space within the nipple filled with hot OZITE insulating compound. The connection is then complete.

U. S. CO. TO MAKE SELF STARTERS.

The United States Light and Heating Company has acquired the exclusive rights to manufacture and sell the Eveland Electric Self-Starter and Lighting Device for Automobiles—both pleasure and commercial types—and it will be known hereafter as the "U. S. L. Electric Self-Starter and Lighter."

This equipment consists of a special motor-generator or dynamo which is applied in place of the usual engine fly-wheel. By its use, no hand cranking is required, while it also furnishes a practically unlimited supply of electric current for use in cranking the engine, as well as for electric search, side and tail lights, ignition, flashlight, electric illuminated signs, etc., all of which is done without added operating cost as the electric current is generated by the gasolene engine from the surplus power that ordinarily is wasted.

There are no gears, chains or other power transmission devices used and no bearings shafts or other complicated parts to the device. The armature is made in the form of a hollow ring about the same proportions as the fly wheel; it is mounted on the engine shaft and takes the place of the fly wheel as a load balancer. The fields are mounted stationary inside the armature drum.

RAILROAD SALES WESTERN ELECTRIC CO.

Mr. Geo. H. Porter, President of the Railway Supply Manufacturers Association, has recently been placed in charge of the railroad departments of what is known in Western Electric headquarters as Central division.

He has charge of the railroad sales in the following branch houses of that Company: Chicago, St. Paul, Minneapolis, Omaha, Cleveland, Detroit and Cincinnati. and Gem.

TELEPHONE TRAIN DISPATCHING.

The Chesapeake & Ohio Railway, which has had for some time more than 200 Gill selectors in service in telephone train dispatching has now ordered from the U. S. Electric Company, 52 additional selectors for a further extension of its circuits.

The Central Vermont Railway has recently received 31 additional Gill selective station outfits with automatic sending keys for the dispatcher's station.

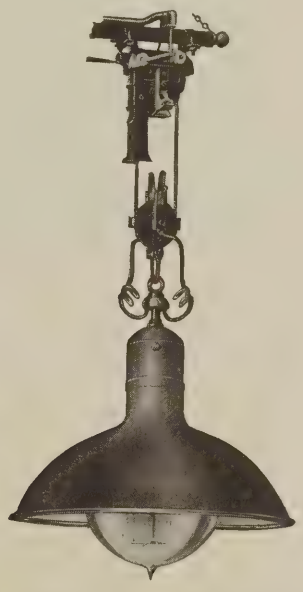
NEW CUT OUT HANGER FOR TUNGSTEN UNITS.

With the recent development of the tungsten lamp and its wide application in industrial fields where lamps are placed in more or less inaccessible places, the question of a suitable cutout hanger so that the lamp may be lowered for cleaning and renewals becomes one of great importance.

Where no provision for lowering is made, lamps and reflectors in inaccessible places are seldom, if ever, cleaned, with the result that there is a great loss in illumination and a general dissatisfaction with the lighting installation. Moreover, any man cleaning a lamp and reflector can do a much more thorough job when it is lowered down on the ground well within his reach than he can high up on a ladder or on a crane.

The Thompson cutout hanger for tungsten lamps is a modification in miniature of the arc lamp cutout hanger described in the February issue of the RAILWAY ELECTRICAL ENGINEER. The mechanism of the hanger is shown very well in the accompanying illustrations, the fundamental principle being that there are two little eccentrically mounted dogs which, on slow release drop into place and engage a pair of hooked fingers; while on quick release these fingers and the lighting unit to which they are attached drop out of the hanger before the dogs have time to fall into place.

Lamp in Position.



Hanger Casing Removed and Lamp Lowered.

There is no jar whatsoever either on raising or lowering. Care should be taken however to have the supporting cord flexible and free from kinks or frictional places which would make this action slow, thereby retarding the release.

When the lamp is lowered it is entirely cut out of circuit. The backs of the two supporting fingers make a wiping contact on the supporting parts attached to the stationary part of the hanger. The counter weight dogs have little if any part in the conduction of current. They merely act as the mechanical support in holding the lamp in place and in pressing the two conducting parts firmly together. When the hanger is once locked there is no strain whatsoever on the cord.

Circuit wires may be carried in conduit direct to the stationary part of the hanger. In fact, this pipe conduit often forms the horizontal member of the lamp bracket when attached to posts.

UTILITY STEAM HOSE COUPLER.

One of the chief causes of deterioration and trouble with steam hose couplers using rubber hose is that in bending the hose upward to couple and uncouple, it becomes kinked which reduces the inside area and also weakens

Hose Coupler Connected.

the hose, causing it to give out at this point. A greater portion of the steam hose failures and renewals are due to this cause. The Utility coupler is designed to prevent kinking the hose. Each coupler head is surrounded by a loose collar. This collar has a projecting hooked lug at one side and helical flange extending nearly around the remaining portion. To couple two heads together it is only necessary to grasp one in each hand, swing them together face to face, so that the hooked lug of each collar engages the helical flange of the other. A twist of about a quarter turn forces the couplers firmly together, making a tight joint. A slight tap with a hammer tightens them so they cannot jar loose on the road. To uncouple; a reverse twist loosens them.

In addition to the saving of hose, this type of steam coupler has other advantages. The gaskets are brought together with their faces parallel so they wear evenly. The helical flanges take up for all wear as it is only necessary to turn the collars until a tight joint is made. No extra locking attachments are needed as the couplers are always securely locked when coupled. The gaskets must always line up and a full 1½-inch opening is insured.

Where metallic joints are used for high pressure dynamo service, this coupler makes an ideal connection, as it is easily coupled and is positively locked.

This coupler is manufactured by the Railway Utility Co., Rookery Building, Chicago, Ill.

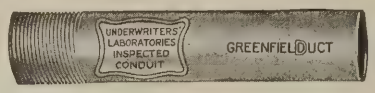
REFLECTING GLASSWARE.

The Opalux Company, 258 Broadway, New York, has issued Bulletin No 11, describing its numerous types of glass reflectors for various conditions of service. List prices and quantity discounts are included.

GREENFIELDDUCT.

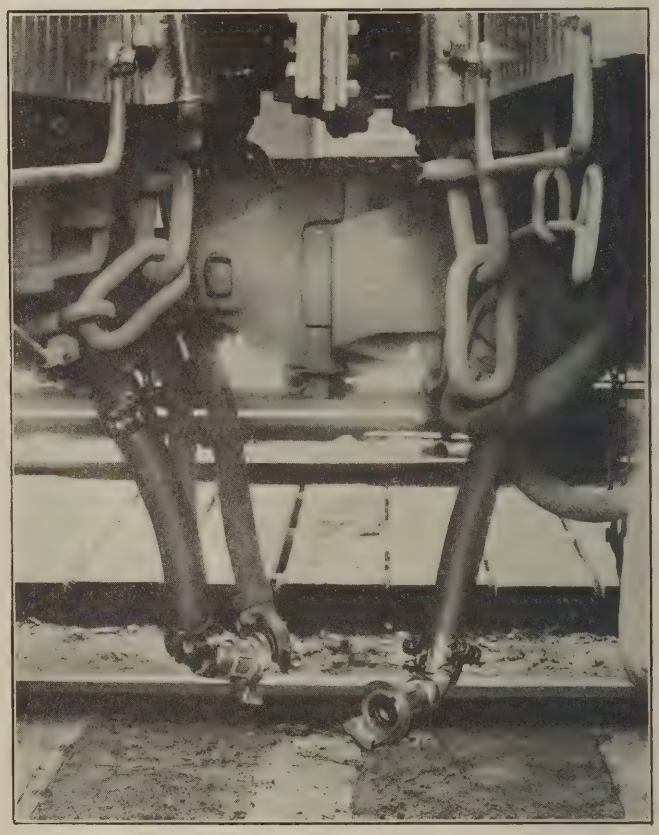
A new type of ridged iron conduit known as Greenfieldduct has been recently placed on the market by the Sprague Electric Co. of New York City.

Manufacturers claim many advantages of Greenfieldduct over other types of ridged iron pipe due to the fact that it is hot galvanized on both the interior and the exterior surfaces.



The special process used in galvanizing this pipe gives a special product which will withstand seven or more dips of the standard copper sulphate test.

This is the same type of galvanizing as is applied to the armor of Greenfield B Cable which long experience has shown to wear unimpared under most severe conditions.



Hose Coupler Disconnected.

PRINCIPLES OF INDUSTRIAL LIGHTING.

This is the title of a valuable little booklet just issued by the Cooper-Hewitt Electric Co. It is in the form of a very comprehensive paper on the subject by Mr. George C. Keach of the Chicago office of that company.

The author quotes largely from various well known authorities on the subject of illumination, co-relating their remarks under various subject heads of, distribution, glare, candle power, illumination intensity, color, reflection, efficiency and effect on the human eye.

It is a liberal education on the subject of optics and illumination for one to read this booklet through very carefully.

A copy will be gladly furnished to any of the car lighting engineers or their assistants on request.

Dope Sheet

Iron Working Machinery—Power to Drive.

Facing 8 Cast Iron Driving Boxes. one side, on Boring Mill made Bridgeport Machine Tool Co., Driven by 220 Volt, 20 Amp. Shunt Wound Motor.

Diameter Inches.	Kilowatt.	Mech. h.p.	Depth of cut.	Feed	Cutting Speed.	Cubic Inches Removed Per Revolution	Cubic Inches Removed Per Minute	Length per Revolution Air Space	Length per Revolution Metal Space
56	2.4	2.82	.21875	0.625	39.5	1.357	3.66	76	100
50	2.8	3.33	.1000	0.625	35.1	.250	.675	117	40
46	2.9	3.36	.1428	0.625	32.2	.311	.841	109	35
38	1.7	2.02	.0714	0.625	26.9	.146	.394	83	33
Note:—Maximum m.h.p.			4.524						
Minimum m.h.p.			0.640						
Average m.h.p.			2.85			Angle of Tool	5°		
56	2.4633	2.8237	.21875	0.625	44	.7656	3.2	72	126
50	2.835	3.23	.1000	0.625	44	.3125	1.3	116	48
46	2.961	3.366	.1428	0.625	44	1.3729	5.7	116	40
38	1.777	2.023	.0714	0.625	44	.1685	.7	88	36
Note:—Maximum m.h.p.			4.524						
Minimum m.h.p.			0.640						
Average m.h.p.			1.951			Angle of Tool	5°		

Iron Working Machinery—Power to Drive.

On large boring mills the maximum power is required when the tool is started from rest to get up to full speed, being the greatest when starting on the point of direct drive.

Size.	Diam. Wk. in Inches	No.Tools Cutting.	Size of cut in Inches.		Time req.for 1 rev. of Table.	Cutting speed ft. per min.	Material	h.p.req. to Drive Mach.
51 in.	47.0	2	1/16x1/4	1/16x1/4	30 Sec.	24.6	C.I.	2.7
51 "	25.7	2	1/32x3/8	1/32x3/8	16 "	25.2	S.	2.0
5 ft.	34.0	2	1/16x1/4	1/16x3/8	25 "	21.4	S.	4.8
5 "	28.0	1	1/16x1/4		25 "	17.6	C.I.	2.9
6 "	8.0	1	1/16x1/4		6 "	20.9	C.I.	2.0
6 "	59.0	2	1/16x7/16	1/16x3/8	48 "	19.3	S.	6.5
6 "	32.6	1	1/16x1/4		3 "	170.0	Copper & Mica	9.6
6 "	57.3	2	1/16x1/4	1/16x1/2	33 "	27.3	C.I.	4.7
7 "	60.0	2	1/16x1/4	1/16x1/4	30 "	31.4	C.I.	2.9
7 "	53.0	2	1/16x1/4	1/16x3/8	45 "	18.1	S.	6.6
8 "	85.5	2	1/16x3/16	1/16x1/4	53 "	25.3	C.I.	3.0
8 "	30.0	1	3/64x3/8		25 "	18.8	S.	3.3
8 "	40.0	2	1/64x1/4	1/16x1/8	29 "	21.7	S.	4.4
8 "	84.5	2	1/16x3/16	1/16x1/8	38 "	24.9	C.I.	3.6
8 "	54.0	1	1/32x3/8		24 "	35.3	C.I.	3.7
10 "	70.0	2	1/16x1/4	1/16x3/8	43 "	25.5	C.I.	3.4
12 "	12.5	1	1/32x1/32		11 "	17.9	C.I.	6.5
12 "	96.0	2	1/16x3/8	1/16x3/8	47 "	32.1	C.I.	3.4
12 "	84.0	2	1/16x1/4	1/16x3/8	57 "	23.1	S.	4.5
12 "	123.0	2	1/16x1/2	1/16x5/8	101 "	19.2	S.	7.2
10-16	73.0	2	1/16x3/8	1/16x1/4	32 "	35.8	C.I.	4.3
10-16	84.0	2	1/32x5/8	1/32x1/8	66 "	20.0	S.	4.8
14 ft.	98.0	2	1/32x3/8	1/32x3/8	80 "	19.4	S.	4.2
14 "	21.5	1	1/32x5/16		17 "	19.9	C.I.	2.4
14-20	172.0	2	1/16x1/2	1/16x1/4	114 "	23.7	C.I.	2.4
14-20	132.0	2	1/16x1/4	1/16x3/8	103 "	20.1	S.	5.0
25 ft.	220.0	2	1/8 x3/8	1/8 x3/8	150 "	23.0	C.I.	4.8
25 "	109.0	2	1/16x1/4	1/16x1/4	67 "	25.5	S.	4.8

Wood Working Machinery—Power to Drive.

Name of Tool.	Material.	R. P. M. Driving Shaft	R. P. M. Tool	Cut.	Horse Power. No. Load.	Horse Power. Ave.	Useful hp. (Ave)
One SP. Borer.		1200	Machine		1.1	5.6	4.5
Small Borer.		450			1.83	7	5.17
One SP. Borer.		800			1.83	7	5.17
Four SP. Borer.	Geo. Pine	310	320	2¼" X 4½"	7.75	10.5	2.75
Radial Borer.		900	970	2" Bit	1.83	7	5.17
Four SP. Borer.		310			7.75	10.5	2.75
New Four SP. Borer.		365			7.75	10.5	2.75
Five SP. Borer.		310			10.3	14.5	4.2
Three SP. Borer.		360			6.8	8.4	1.6
Two SP. Borer.	Gr. Oak.	360	400	1¾" X 8"	6.9	8.8	1.9
One SP.Borer.		280			.67	1.65	0.98
One SP.Borer.		600	M'C'H.		.48	1.0	0.52
One SP.Borer.		650	"		1.83	3.2	1.37

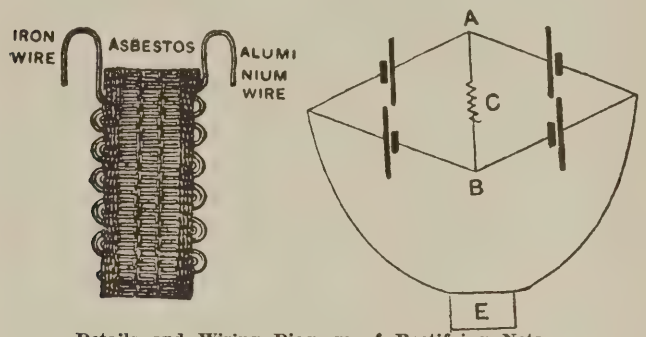
Wood Working Machinery—Power to Drive.

Name of Tool.	Nature of Material	R. P. M. Driving Shaft.	R. P. M. Tool.	Cut.	Cu.in. P.Sec.	Horse Power No. Load	Horse Power Max.	Horse Power Ave.	Useful hp.(av)
Three Spindle Boring Machine	Running Light	400				0.45			
	Oak			2"X12½" Hole	3.66	0.45	3.25	2.5	2.05
Three Spindle Boring Machine	Running Light					0.7			
	Oak			2"X 9" Hole	1.9	0.7	4.0	3.0	2.3
	Oak			1 3/8"X 9" Hole.	2.4	0.7	3.2	3.0	2.3
Two Side Tenoning Machine	Ash	1100					3.0	2.3	
	Running Light					4.0			
Large Tenoning Machine				3½"X 5"Deep X 10"	7.8	4.0	11.0	8.5	4.5
				3½"X3½" " X 10"	12.5	4.0	9.0	8.5	4.5
				4½"X7½" " X 10"	15.9	4.0	13.5	11.5	7.5
				3½"X7½" " X 10"	18.7	4.0	13.5	12.0	8.0
				3½"X7½" " X 10"	23.4	4.0	15.25	13.0	9.0
Gainer 16" Head	Running Light	600	1700			3.0			
					9.3	3.0	10.5	8.5	5.5
Turning Lathe	Running Light					0.75			
	Cutting					0.75	2.5	2.0	1.25
Planer Knife Grinder	Running Light					0.5			
	20" Knife		210			0.5	2.4	1.9	1.4
	Running Light	600				2.8			
	Oak			Cut 1½"X4"X2" Deep	1.38	2.8	4.8	4.2	1.4
Rotary mortising Machine	Oak			Gaining 5/8"X5½"X17½"	2.19	2.8	5.5	5.0	2.2
	Oak			Countersink'g Cup Washers.Outside 4 3/8"X½"	1.64	2.8	6.0	5.5	2.7
				Inside 3 7/8"X3/8"					

A NEW RECTIFIER.

The London *Electrical Review* of April 26th, 1912, contains a description of the "rectifying nets" of Mr. C. Schniewindt.

This rectifier is based on the well known principle that an aluminum electrode permits the current to pass only when it is cathode and not when it is anode. The novel feature seems to be the construction of the "rectifying nets." These nets are placed in glass jars filled with water with a small quantity of bicarbonate of soda, which



Details and Wiring Diagram of Rectifying Nets.

are afterward connected up like cells. The special nets are composed of iron and aluminum wires woven with asbestos, as shown in the left-hand diagram of Fig. 1. The connection of four "rectifying nets" in such a way as to utilize both half waves of the alternating current in the production of the direct current is shown in the right-hand diagram of Fig. 1, in which the short dashes represent the aluminum wires and the long dashes the iron electrodes. Between the points A and B a direct current is obtained at about 75 per cent efficiency, the heating of the electrolyte accounting for the losses. E represents the source of alternating current and C the direct-current consuming circuit.

A STEAM TURBINE MONUMENT.

The General Electric Company has re-erected in the centre of a park plot in its grounds at Schenectady, N. Y., the first 5000 kw. Curtis steam turbine installed in the Fisk Street Station of the Commonwealth Edison Company of Chicago. It is to serve as a memorial to the rapid development of the steam turbine unit applied to central station service. This turbine was installed in the Fisk Street Station eight years ago, being put in operation on October 2, 1903, and remained in continuous service until May 29, 1909. It was specified in the contract by President Insull when this unit was replaced that it should be set up as a monument to commemorate the great step in engineering which its installation marked. A bronze tablet detailing its history has been placed on the turbine.

ECONOMY FUSE & MFG. CO. MOVES TO CHICAGO.

The Economy Fuse & Manufacturing Company have moved their general office and works from the Phipps Power Building, Pittsburg, Pa., to larger and better quarters at the corner of Kinzie and Orleans Sts., Chicago.

The additional space obtained by the company has increased their factory facilities four or five hundred per cent. The rapid increase in the company's western business necessitated their moving to a more central location and larger quarters where more attention could be given customers' orders.

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DICKINSON MANUFACTURING COMPANY, Springfield, Mass.
KURT R. STERNBERG, Treas. and Genl. Manager.

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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Our Semi-Annual Convention.

This is the first year that the A. R. E. E. has held its Semi-Annual June Convention at Atlantic City, and it seems almost a foregone conclusion that it should have been the most interesting and best attended semi-annual convention which the Association has ever held. The wonderful show of exhibits on the Million Dollar Pier undoubtedly served as a big attraction for drawing railroad men to the Convention.

Moreover, with the increasing number of railroad men who belong to both the A. R. E. E. and the M. C. B. Associations, it becomes much more convient, in fact, makes it possible for some members to attend both meetings who would not otherwise attend either, when our semi-annual conventions are held at the same time and place as the M. C. B. Convention.

However, aside from the mere convenience to certain members, and aside from the advantages of being able to see the Atlantic City exhibits, there is a great element of good in bringing the two Associations more closely together, which cannot but result in giving the A. R. E. E. the standing among the Railroad Associations of the country it so thoroughly deserves, and at the same time make for a more effective standardization of all car lighting equipment.

All who have the best interests of A. R. E. E. at heart will appreciate this point and urge that all our semi-annual conventions in the future be held at the same time and place as the M. C. B. Convention.

Methods of Axle Generator Control.

Much as has been said about the various methods of charging storage batteries by the various systems of constant charge at high rate, constant charge at low rate, taper charge, constant potential, and combination current and potential control as is now advocated by various manufacturers of axle equipments. Each of these systems has had its ardent advocates and been more or less generally popular in its turn. The new system of constant current with a limiting voltage feature at the end of charge, as outlined by Mr. Bliss at the recent Atlantic City Convention, however, seems to possess merit.

It is pretty generally appreciated that the conditions under which axle lighting equipments must operate on railroads are so uncertain and so severe, that it becomes almost impossible to set a constant current or battery current regulator at a certain value with any reasonable prospect of the storage battery receiving its proper amount of charge. Necessarily, the regulators in this service have invariably been set high so as to be on the safe side, and this has resulted in much chronic overcharging of the storage battery.

The stop charge relay was developed 6 years ago in an effort to eliminate this continued overcharging, but experience has demonstrated pretty well that it does not fill the bill. The voltage of a storage battery is dependent upon so many variable factors such as rate of charge, temperature, condition of the plates, i. e. (whether they are slightly sulphated or not) their age, etc., that it cannot be employed with a degree of satisfaction in limiting the charge.

In very cold weather, or if the plates have become slightly sulphated, it will be found that the battery voltage raises abnormally high on charge and will reach the point of cut off before the battery is fully charged. The charge is then stopped too soon and this undercharge will cause further sulphation of the plates and result in a higher voltage on the next charge and even a more premature cutoff.

On the other hand, if the battery is warm or the electrolyte too strong, the voltage at the end of charge may never reach the point of cutoff, and as the battery continues overcharging, will warm up more and actually cause the battery voltage to fall away still further from the point of cutoff, as the destructive overcharging proceeds.

It is almost self-evident that the operation with a stop charge device will seldom be right—but the advocates of the stop charge relay say, "it is near enough for practical purposes." As a matter of fact however, as shown above, the battery voltage may never reach the cut-off point, while on the other hand it may continue to reach that point before the completion of charge, causing an increasing sulphation of the plates.

The combination current and voltage control as now advocated by the various manufacturers of axle equipments, however, may offer a solution to the difficulty. It then becomes possible to provide a taper charge or reduce the charging current to a low value slightly befor the completion of charge. The limiting voltage maintained by the voltage controlling device can then be set low enough so that it will never fail to operate even at high temperatures, strong electrolyte, or at the low charging rates sometimes encountered. In other words, this becomes effective just before the completion of charge in all cases. The charge at low rate which is

maintained thereafter, however, completes the charge of the storage battery very effectively, yet is not at a high enough rate to cause serious overcharging or overheating of the battery.

A pretty good analogy of battery charging is obtained every time you fill a glass full of water from a faucet with a good pressure behind it. It is all right to turn the water on full and strong when you begin to fill the glass, but if you leave it turned on full blast until overflowing and then suddenly shut it off, you will find your glass is only partly filled. To fill the glass level full of water, you must partially turn off the faucet when the glass is nearly filled, so that the last part is added gently.

While in stationary battery practice it may be all right to maintain the charging current constant right up to the completion of charge, in axle lighting service where a voltage cutoff is depended upon, conditions are very much like that of the simple illustration above. It is much safer to reduce the charging current to a low value just before the finish of charge so that the overcharging, which usually follows, will not be of a destructive nature.

Association News.

The October Convention.

Arrangements have just been completed by a joint committee of the Association of Railway Electrical Engineeers and the Railway Electric Supply Manufacturers' Association to hold the next annual convention of the Association at the Auditorium Hotel, October 21-25.

The request for space last year so far exceeded the capacity of the exhibit hall at the La Salle Hotel, that it was considered necessary to make this change in the place of meeting so that more spacious quarters for the Convention exhibits could be procured.

President Porter, of the Manufacturers' Association, has appointed the following committee chairmen:

Exhibits—W. F. Bauer.
Membership—J. Scribner.
Badges—G. H. Atkin.
Auditing—J. M. Lorenz.
Publicity—Edw. Wray.
Entertainment—Geo. H. Porter.
Sub-Committee:
Reception and Dance—W. M. Lalor.
Theatre—Otis B. Duncan.
Banquet—J. J. Schayer.
Speakers—Geo. H. Porter.

It is a little early to judge, but from all the present indications, we think we are safe in prophesying this year's Convention is going to be even bigger and more successful than the 1911 Convention—and that's going some.

Larger Armature Pulleys.

Except when trains are operated over mountain divisions or in slow suburban service, it will almost invariably be found that the train speed curve raises quickly to a value of 25 or 30 miles per hour. This means that what is known as the "critical speed" of an axle equipment, usually 12 to 15 miles per hour, is very quickly passed. In fact, in the majority of cases, the equipment would cut in almost as soon were the critical speed 25 miles an hour instead of 12 miles.

To effect this change in critical speed it is only necessary to employ a larger armature pulley. By using a 14 in. pulley instead of an 8 in., the average armature speed will be reduced to practically one-half, which will result in a great decrease in wear on bearings, commutator, brushes, armature maintenance, etc.

The life of belts also will be very materially increased because the greatest part of the trouble at the fastener is caused by engaging with a small armature pulley. If this pulley be made larger, the angle of bending as the fastener engages the pulley, will be materially lessened.

On mountain divisions where the average speed is oftentimes 18 to 20 miles an hour, this is, of course, out of the question, but there is no reason why a larger armature pulley cannot be employed to very great advantage on the majority of car lighting equipments.

Voltage Control of Axle Equipments.

With all the exhaustive development work which the manufacturers of axle lighting equipments have carried on during the past 10 years, the matter of potential regulation has, until very recently, been considered both unnecessary and undesirable.

In the original constant current regulators there was but a mere pretense made at voltage regulation, and since the inherent principle of the constant current regulator is such that it will maintain a predetermined current value regardless of the voltage required, the lamp voltage followed very closely the rise in battery voltage as the battery became charged.

This, of course, was an objection to the constant current machine, but the advantages, simplicity and reliability, were of greater importance; the mere variation of a few volts on the lamp circuit was not, in those days, considered serious.

In 1905 what is known as the McElroy system was developed and a few equipments placed in service. This operated on a voltage control principle where a few turns of heavy wire wound on the voltage control coil which prevented excessive battery current flow. For some reason or other, probably on account of mechanical defects, this equipment never got beyond the experimental stage.

We have always maintained in these columns that the voltage of a storage battery is no reliable criterion of its condition of charge on account of the great influence of certain variable factors such as temperature, current rate, conditions of plates, etc. Accordingly, the operation of so-called stop charge devices which depend entirely upon battery voltage for their operation and assume the voltage at the end of charge as a constant and reliable value, cannot operate with more than temporary success.

Although the voltage of a battery at finish of charge is not a fixed value and should not be used as an absolute basis in controlling the equipment, it can no doubt, be employed to advantage as one of the determining factors in controlling the operation of an axle equipment.

One manufacturer has, for some time, been operating equipments on a combined voltage and current principle, in which the voltage regulation becomes effective after a certain point of charge has been reached. This point at which the voltage regulation becomes effective is well below the overcharging voltage at normal temperature of current; so the varying conditions of temperature and current rate should not interfere with the effective operation of the equipment.

There is not the slightest doubt but that the activity of the various manufacturers in developing voltage controlling devices marks an epoch in car lighting history, and will result in much better operation of the equipment, from a battery point of view, at least.

Overcharging should then be largely eliminated, and any formation of sulphate on the plates should be quickly broken down by the high current rate at the beginning of charge.

Semi-Annual Convention, A. R. E. E.

ATLANTIC CITY, N. J. JUNE, 14, 1912

The Semi-Annual Convention of the A. R. E. E. held June 14th, at Atlantic City, was by far the most successful Semi-Annual Convention ever held.

There were over 60 in attendance at both the morning and afternoon sessions, and the topics and lively discussion which are abstracted under the Convention Report in this issue, made the Convention a very interesting and most instructive one.

The Convention Special left Chicago Tuesday afternoon, June 12th at 3 o'clock on the Pennsylvania and reached Atlantic City Wednesday afternoon at 2.10. The train of 13 Pul'mans was filled with railroad officials and supply men, and everybody had a most enjoyable time. The weather was cool and the trip delightful.

There wasn't supposed to be much in a social way this year at Atlantic City on account of the change in entertainment plans of the M. C. B. and M. M. Associations, but this bunch of snap shots shows pretty well that "Jack" didn't have quite "all work and no play."

Meloy on the "Board Walk."

Out for an Airing with Their Nurse.

Can't You Hear Him Yell?

Off For A Swim.

Quantzintecomatzin (Royal Diner) (Which One?)

Hutch in an Argument with Nature.

All Aboard.

Posing.

Morning Session

President's Address.

"Gentlemen:—In spite of the 'hard times' considerable progress has been made in steam railway electrical work for both lighting and power purposes. While perhaps no startling inventions have been made, the advancement in economy and improvements has been considerable.

"In lighting, special study has been made by several investigators to determine the effect of various types of illuminants and of the various conditions and the character of and the number and location of light sources upon visual acuity and upon eye strain. It is realized that the condition of the eyes has considerable influence upon the health and personal comfort of people, so that eye strain may destroy the effect of otherwise luxurious trains and expensive service and 'spoil the trip.' Consequently sufficient and properly directed light becomes quite necessary to produce comfort and leave a delightful memory with the passengers after their return from the

trip. Air washers to cleanse the air supply, vacuum cleaners to remove the dirt without raising most unsanitary dust, to the great annoyance of the passengers, and indirect lighting have all been tried recently, with varying success, to add to the comfort of passengers in the best trains.

"With the improvement of lamp regulators, there has come a tendency to use regulators designed to maintain reasonably constant the voltage, instead of the current, the idea being that the battery can be more quickly and more economically charged in this way. Provision is required in the regulation to limit the output of the dynamo when the load is heavy or the battery is discharged.

"During the past year I believe that our committees have all done very good work. I know that the Executive Committee has always had well attended meetings and considerable interest has been shown in various ways in the work of the Association, considerably more so than in previous year, perhaps.

While much has been accomplished, there still remains a very great deal to be done to promote uniformity in apparatus and practice, and I think that we should get together more frequently in small groups and engage in frank discussion of conditions, also of apparatus, of practice and of opportunities offered to increase the quality and efficiency of service. More careful analysis and study of actual results is urgently needed to promote a more satisfactory progress.

'By keeping our committees informed of the facts brought out in our small discussions,, we can greatly enhance the value of the committee work, and its helpfulness to us all, and build up standard practice. This kind of work is required to obtain a standing and to command respect for our Association. If we do not do this, we waste our time.

"Let us get busy today and put ginger and lots of enthusiasm into our work.

"I might add that various efforts have been made to bring the different allied associations together, so as to properly co-ordinate the work of the Illuminating Engineering Society, the American Institute of Electrical Engineers and other Associations so as produce the best results, and not all be working over the same ground."

The report of the Secretary-Treasurer was then read and accepted.

Secretary Andreucetti presented some letters from the Mayor of St. Louis, the President of Missouri and various St. Louis Associations, inviting our Association to hold its next annual meeting in that city. These were laid on the table for further consideration at the annual convention.

The Secretary also presented a letter from Mr. F. L. Hutchinson, Secretary of the American Institute of Electrical Engineers, advising of the appointment of Mr. J. H. Davis and Mr. Chas. R. Sugg to serve as members of the committee on Organization of the International Electrical Congress to be held at San Francisco, September 1915.

It was suggested that the Association bear at least a part of the expenses of these gentlemen in case it becomes necessary to hold any meetings in San Francisco, but this matter was referred to the executive committee for action.

Another letter from the Electrical Testing Laboratories extended a cordial invitation to all of the members who wished to visit the laboratories. Subsequently a small visiting party was arranged and made a very interesting tour of the testing laboratories.

The report of the sub-committee on ball bearings was then read by Mr. Sloan.

Committee Reports

Report of Special Committee on Standardization of Ball Bearings for Axle Generators.

Your Sub-Committee on the question of standardizing ball bearings for axle generators submits the following as their recommendations:

First: Pulley and commutator end bearings should be the same size.

Second: The pulley end bearing should be a press fit within the limits given by the manufacturers of ball bearings. The bearing should be mounted directly on the axle. That is, construction requiring a sleeve for this bearing is not approved. The bearing should "Float," or in other words, should only be required to take radial load.

Third: The commutator end bearing should be mounted on a sleeve, and the bearing secured so that it will have no play longitudinally to the shaft. In other words, this bearing must be mounted so it will take the end thrust.

Fourth: Open ends of housing around each bearing should be provided with grooves, and the outer end of the housing for the pulley bearing should have two grooves and one felt washer.

Fifth: Each bearing must be mounted on the shaft between a shoulder and nut, and locked securely in place.

Sixth: The size bearing should be that known as the 412.

There was considerable discussion as to the size of the bearing but on the final vote the majority of the committee were in favor of the 412 size.

Seventh: The nipple for the grease gun shall be of 3/8" pipe, with standard pipe thread, properly capped.

The question of standardizing the pulleys was discussed at length but as standardizing the pulleys necessarily affected all generators now in service, and as each make of generator uses a pulley that differs in some essential dimension from pulleys of all other makes it was thought best that this question be referred back to the Committee on Standards. It was admitted by all that from the engineering side there was no reason why the pulleys could not be made standard, and further that from the operating side it would be advantageous to do so. From the commercial side, however, the fact that of the pulleys that have been supplied by the manufacturers no two makes are interchangeable and that there are thousands of these pulleys and shafts in existence, was considered of such importance that your committee, as a whole, did not feel that they could make any recommendations.

Some of the members of the committee, while appreciating the point of view taken by the others, namely, the objections from the commercial side, felt that undue weight was given these objections. The view these members took of the matter was that the railroads now have to carry various shafts and pulleys—that these shafts and pulleys wear out or are broken, and that on this account the new shaft and pulleys could be ordered in accordance with the standard recommended. This procedure would entail carrying extra shafts and pulleys, but eventually would result in all pulleys being interchangable on all generators, and this condition would be a decided advantage to the railroads and would not be a hardship to the manufacturers, provided the rail-

road companies in ordering shafts and pulleys would clearly specify what was wanted.

The committee does, however, recommend that the armature shaft pulley keys shall be of ⅜" square stock and the key-way in the shaft and pulley bore shall be cut parallel to the axis of the shaft.

The committee also discussed the question of lubricant to be used with the ball bearings and recommends that this lubricant shall conform to the following:

First: Shall not, when new, contain either free acid or alkali.

Second: Shall not, when old, contain free acid.

Third: Shall not oxidize or materially evaporate.

Fourth: Shall not pound thin in service.

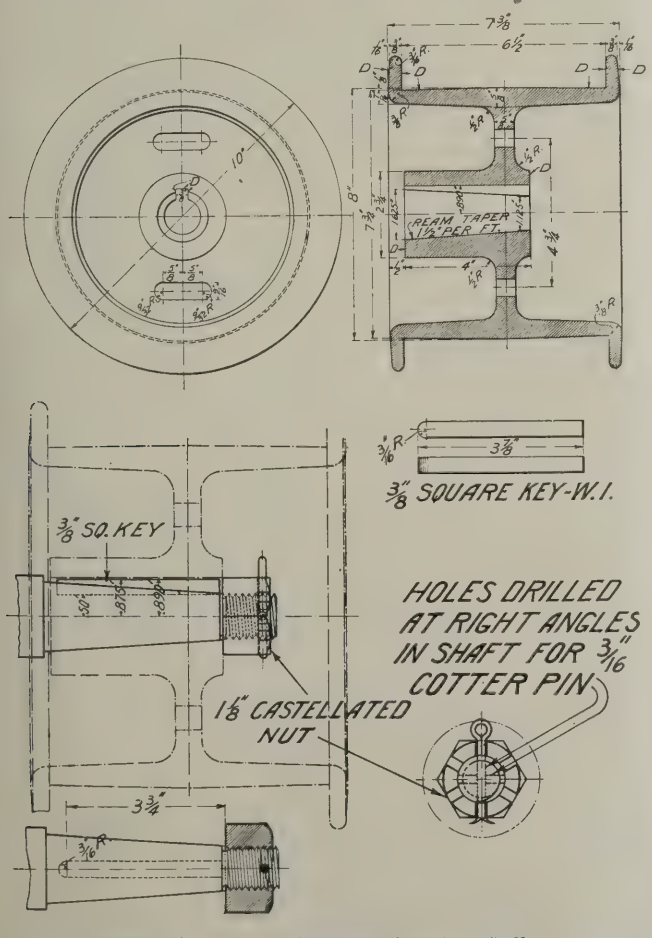
Also that the lubricant shall be applied as follows:

Before placing generator in service for the first time, the bearings shall be filled with lubricant. When the generator is in service the lubricant is to be injected with a "Gun" at such intervals as the railroad company may determine as necessary.

Respectfully submitted,

W. L. BATT,
W. L. BLISS,
W. F. BOUCHE,
T. V. BUCKWALTER,
H. E. HULSE,
N. E. LEMMON,
T. L. MOUNT,
R. M. NEWBOLD,
F. H. POOR,
J. R. SLOAN, Chairman.

Mr. Sloan of the Pennsylvania advised as supplementing the report of the committee on ball bearings, that he had gone into the matter of a standard armature pulley very carefully and would gladly submit prints to any desiring them. Mr. Sloan's drawings are however, published herewith although they do not become a part of the committee report.



Design of P. R. R. Standard Armature Pulley.

Standards.

D. J. Cartwright of the Lehigh Valley, chairman of the Committee on Standards, then outlined the proceedings of a recent meeting of the Committee on Train Lighting Practice of the M. C. B. Association, of which he is a member.

Twenty-two of the twenty-seven recommendations made by the A. R. E. E. 1911 Convention, are included in the M. C. B. Committee report. Of the remaining five, three have been referred to the Arbitration Committee of the M. C. B. These refer to No. 27, Generator Clearance; No. 19, Charges for service given foreign cars; and No. 17, relating to straight seat on car axles. Two of the A. R. E. E. standards were omitted from their report, as follows:—No. 23, Location and Construction of battery boxes, and No. 27, 6 in. clearance above top of rail.

Mr. Cartwright pointed out that in our recommendation No. 10, that generator fuse "may" be installed beneath the car, when wiring is not done in metal conduit, the M. C. B. committee insists on these fuses being installed in all cases; these fuses, however, to be at least 100% above the capacity of the fuses on the switchboards protecting the same leads.

Mr. Cartwright said that he favored making this optional with each railroad and asked for an expression of opinion from other railroad men present.

Mr. F. E. Hutchison of the Rock Island said that even with our present equipment it was difficult to maintain terminal blocks, etc., and that the addition of two more fuses beneath the car would involve more trouble than the advantages would warrant. He said it was hardly considered necessary in stationary work to place circuit breakers and fuses right on the generators themselves in addition to breakers and fuses on the switchboard.

He felt that when wiring was done in conduit it was entirely unnecessary to require this additional circuit protection.

The sentiment of the meeting seemed to be rather opposed to the use of extra generator fuses, and a motion was passed to that effect.

Illumination.

In the absence of Chairman Gilman, the report of the Committee on Illumination was then briefly outlined by Mr. A. J. Sweet of the Nelite Works. He said that they planned to cover two general fields in their report: One, summarizing the proposed series of tests on postal car illumination, and the other, to cover a general discussion of accepted theories and of illumination as applied to railroad stations, offices, yards, industrial plants, etc.

Specifications.

Mr. J. R. Sloan than presented the report of the Committee on Specifications under its various subdivisions of belts, lamps, and rubber covered wire. He said that a large number of samples of belting were obtained from different manufacturers and a series of tests run upon these samples. Based on results obtained from these tests, tentative form of specification was drawn up and submitted to the various manufacturers of car lighting belt. Manufacturers criticisms have subsequently been received and the first specification is being revised in the light of these criticisms and further tests that have been made.

As to the Sub-committee on Lamps, Mr. Sloan said they had held no formal meeting as yet, but had informally agreed that the report should be divided into two parts: one to recite a detailed description of the lamps recommended for purchase, the conditions they must meet and the methods of inspection and testing; two, to cover instructions, (to the ordering and purchasing departments of the purchaser), relative to the proper method to be pursued and the information necessary to be given in the ordering of lamps.

Part one should be sub-divided approximately as follows:—

1st General requirements.
2nd Definitions and standards.
3rd Method of inspection and test.
4th Physical characteristics.
5th Electrical characteristics.
6th Schedules.

Mr. Sloan said that the Sub-Committee on Rubber Covered Wire had been making good progress; the various members have prepared preliminary specifications and these were submitted and discussed at a meeting of the committee held in New York, April 26th, 1912. A preliminary draft of the committee report was drawn up embodying the results of the day's discussion and copies of this are now in the hands of the members for further discussion. It is hoped that two or three more meetings will result in a complete series of wire specifications satisfactory to both consumer and manufacturer alike.

Improvements.

A progress report of the committee on improvements was presented by Chairman Meloy, of the Lake Shore, and showed that an active campaign among manufacturers was being carried on by the committee so as to have the 1912 report include all improvements made during the past year.

Train Lighting Practice.

Mr. F. E. Hutchison, of the Rock Island, then presented the progress report of the Committee on Train Lighting Practice which was as follows:

"Battery Charging:—The matter of charging has been discussed at length as to straight charges, and now the Pennsylvania people are going to high charges.

'Charging Plants:—There is a great deal in this subject, methods of washing batteries and arrangement of battery houses and details of inspection, are points that we will cover, also going into the matter of organization, outlining the organization of the larger terminals of the various railroad companies. We have figured that two men can very easily inspect twelve axle equipments a day, exclusive of battery, with the aid of shopmen for repairing the dynamos, over-hauling them and fixing up all parts. We have gone into the subject of organization quite extensively, and I believe that it would be almost an impossibility to lay out any definite organization that would meet all the conditions on the various railroads."

The Committee on Data and Information reported only indefinite progress and the promise of a good strong committe report at the annual convention.

Secretary Andreucetti presented a letter from Mr. A. J. Farrelly, Chairman of the Committee on Wiring of Buildings, in which he reported that several specifications covering different phases of the work, are in a preliminary state.

President Frost urged that more committee meetings be held and said, that invariably where a railroad man took the trouble to attend one of these committee meetings, he always carried away with his some of the experience of others present which might be of great value to him in his work. He felt that instead of considering these meetings as a burden, as some railroad men do, they ought to look on them as a special opportunity for them to get some good ideas and experience.

Mr. Hutchison suggested that it would be a great help to committee men if members would make a memorandum to committee chairman of any suggestions along the particular line of work taken up by that committee that might occur to them.

Afternoon Session

Meeting adjourned.

The afternoon session was opened by an informal talk on the individual motor drive in railroad machine shops by A. I. Totten and Mr. F. H. Hersch.

Mr. Totten's remarks are as follows:—

Electrical Equipment in Railroad Shops

A. I. TOTTEN and F. H. HERZSCH

Informal Talk by A. I. Totten, General Electric Co.

Mr. President—Gentlemen!

The rapid strides in the development of shops for maintenance of locomotive and car equipments on the Steam Railroads, has called for unusual endeavors on the part of the electrical department, in order to keep abreast of the times and provide satisfactory and economical means for operating the shop machinery and furnishing lights for the property.

The first modern shops constructed during the latter part of the nineteenth century, had installed machinery which was operated in groups by comparatively large motors. At that time, the individual drive for machine tools was practically unknown. The first step toward the operation of machines individually, was the multiple voltage system, originally advocated by the Crocker-Wheeler Company. Several shops were equipped with this system, notably the Collinwood Shops of the Lake Shore & Michigan Southern Railroad and the McKees Rock Shops of the Pittsburg & Lake Erie Railroad.

About ten years ago, a scheme, whereby motor speeds could be varied by weakening the field of the motor, was devised and this method is practically the only one in use today, when making installations where a constant horse power must be maintained, and variable speed provided.

The alternating current motor was not used in any of the first modern shop installations, but in more recent years, the alternating current motor for constant speed work is rapidly superseding the direct current motor. In a great many cases, however, both alternating and direct current is used, the former for constant speed machinery and the latter for variable speed machinery, cranes, transfer tables and hoists. It has now, however, been successfully demonstrated that alternating current motors are wholly applicable for hoisting duty and other work of like character.

The power plant equipments have also passed through the various stages, beginning with engines, belted to generators and progressing through the direct connected engine and generator units to what might now be termed the "turbine age." It might be safely stated that no power plant is constructed at the present time, without the installation of turbines being given the most careful consideration. In the case of comparatively large shops,

the standard power plant equipment, generally consists of alternating current turbo generators with motor generator sets installed to furnish direct current for the operation of variable speed machine tools only. Some shops have been constructed, however, in which all machinery is operated by alternating current, thereby obviating the necessity of using motor generator sets in the power plant. The step toward the exclusive use of alternating current for shop operating purposes, has been checked by the recent development of reversing motor driven planers, designed for direct current operation only. The enormous saving which can be affected by the installation of reversing motor driven planers, makes it advisable to install direct current for driving them, if for no other purpose.

I will now briefly review some of the more important progress made in the design of new equipment during the past year.

It had always been the usual practice to install face plate types of rheostats for starting constant speed, direct current motors. These as a rule have proven a source of trouble and their maintenance depends, to a great extent, upon the gray matter used by the operator in their operation. If started too slowly, a severe flashing at the first point results, necessitating, as a rule, repairs of some kind, before rheostat can be placed in suitable operating condition again. If started too fast, the result is to throw out the circuit breaker, thereby causing delay and annoyance.

The Company, whom I have the pleasure of representing, have now developed an automatic contactor, operating on the current limit principle, for use in connection with a push button control, and there is no doubt but what this will be used practically exclusively for direct current motor starting equipment. The Chicago Railways Company, installed automatic control in their Chicago shops about two years ago, and undoubtedly they were just about two years ahead of the times. In their shop installation the machine tool is started and stopped by push buttons. This takes the matter entirely out of the hands of the operator, which is a most desirable feature. I trust that those present will bear the foregoing in mind when writing specifications for new motor equipments, as otherwise, they will be installing apparatus which will undoubtedly be considered obsolete in the very near future.

You are possibly all aware of the fact, that the electrical companies, now have on the market, automatic control equipment, especially designed for use in connection with motors operating driving wheel lathes and car wheel lathes. These control equipments are provided with four push buttons, for the following purposes, namely:—starting, stopping, retarding speed and accelerating speed. By the means of apparatus of this character, the speed of machine can be reduced so the tool may pass through hard spots in the tire without injury. An equipment of this character, also makes it possible for the operator to control the motor from one or more convenient points.

I have already mentioned briefly about the new reversing motor driven planer equipments. It has heretofore been quite a problem to satisfactorily operate planers with motors, especially when necessary to apply the motor to an old machine. The motor was, as a rule, mounted on top of the housing and power transmitted through gears and belted to the pinion below the planer. With the newly developed reversing motor driven planer equipment, the motor is direct coupled with the lower shaft of the planer and all belting and part of the gearing eliminated. The cost for applying one of these equipments to an old planer would probably not exceed $25.00, inasmuch as a coupling only would be necessary and the scrap value of the belting, pulleys, etc., removed from the planer, will probably more than compensate for the cost of applying the reversing equipment.

It has been estimated that the reversing motor, when applied to a planer, causes a saving in time required to do a piece of work of approximately 50%. No doubt, this sounds like a broad statement, but it is nevertheless true. We have installed in our Works at Schenectady, a number of these equipments, and in each case, have been able to reduce piece work prices, without any objection on the part of the operators, due primarily to the fact, that a much larger output can be obtained. As a matter of fact, the increased speed of acceleration alone of the direct connected motor over the old method, saves in the neighborhood of 25% in time. In addition to this, we have the advantage of speed control inasmuch as practically any reasonable cutting speed or return speed, can be obtained by simply moving the field rheostat handle.

A few brief words in connection with wiring for shop motors and lights, may not be amiss. It was formerly the practice to run the wiring around the shop in the open, from joist to joist. This was a constant source of trouble, as the wires were being constantly disarranged by ladders, etc. There was also, as a rule, an excessive fire risk. In more modern shops today, the wires are run in conduit throughout, the wires running from the main switchboard and power house to distributing panels, and from these to the motors. A separate switch and fuses on the distributing panel for each motor, obviates the necessity of having a switch at the motor, although it is most desirable to have a circuit breaker in the case of direct current motors and overload relays in the case of alternating current motors, as a form of protection to the motor. A no voltage release in each case, should also be provided.

In connection with the lighting, I think it might safely be said, that the carbon arc lamp is rapidly going out of use. When the enclosed arc lamp was developed twenty or more years ago, it was looked upon as a wonderful thing, as compared with the older type of open arc. Now the enclosed arc has proven uneconomical as compared to flaming arc, magnetic arc and tungsten lamps for shop and yard lighting. In the case of shops with low ceiling, tungsten lamps are nearly always suitable. For shops with high roofs, such as erecting shops, blacksmith's shops, etc., an installation of flaming arc lamps will in nearly every instance prove desirable. For outdoor lighting, we have the choice of three lamps, namely:—tungsten, flaming arc and magnetite, the choice depending upon local conditions.

I would like to make a few remarks on the subject of specifications for electrical apparatus. I receive, from time to time, specifications prepared by the various railroad electrical engineers, which it is practically impossible to meet. In some cases, a full load temperature of 35 degrees and 25% overload temperature of 40 degrees is specified. This is a condition which cannot be met. If the full load temperature is 35 degrees, the 25% overload temperature will be more than 40 degrees. This is merely an example of some of the specifications and I would request the gentlemen present to prepare their specification, in the future, so that, if possible, they correspond to the American Institute of Electrical Engineers standards, in order that there may be no difficulty in submitting propositions on machines to meet your requirements.

It has been stated to me several times, that the qual-

ity of apparatus, such as motor generators, etc., now being manufactured by the electrical companies, is not equal to the quality of similar apparatus built ten years ago. This, gentlemen, is a most erroneous statement. The quality of electrical apparatus is improving every year and the material used in its manufacture, is proportioned so as to give the maximum output with a minimum temperature rise and provide sufficient stability for mechanical purposes.

You will probably recall the first induction motors placed in the market, which had an overload capacity of possibly 100%. This did not mean that they were exceptionally good motors, it was merely a demonstration of the inability of engineers of that period, to design motors having an output corresponding to the rating. In other words, they were entirely too conservative, trying to avoid the possibility of failure. It is true that both motors and generators manufactured today, are much lighter in weight than those built ten or fifteen years ago, but these machines are designed so as not to exceed the temperature rating specified. They have a higher efficiency than the older types, so it certainly cannot be said that the manufacturing art is deteriorating.

I think that is all I have to say, gentlemen. I especially want to impress upon you the value of standardization in your specifications and to request that in placing requisitions covering material, you indicate clearly the apparatus to be furnished, as otherwise you merely get the standard equipments turned out by the various electrical manufacturers and the standard equipment does not include the refinements which are now necessary in order to keep the electrical end of the shop installation on a par with the balance of the engineering construction. If the large electrical companies making a specialty of following the steam railroads' requirements, in order that they may design apparatus applicable to their purpose, attempted to quote upon these special accessories which I have recommended, the quotations would, undoubtedly be rejected by your purchasing departments on account of price.

I thank you for your attention.

Mr. F. H. Herzsch, of the Westinghouse Elec. & Mfg. Co., then continued the discussion on electrical operation of railroad machine shops as follows:—

"The Railroad repair shop has one feature, the source of power, which is very important consideration. The development in size and reliability of the central stations is making it an open question whether it is really cheaper to generate the power or to purchase it from the central station.

Each railroad shop has its own peculiar conditions and each shop should be investigated by an expert commercial engineer to determine if such a saving in operation could not be effected by the purchase of power to make it well worth while.

There are many conditions, as have been mentioned by Mr. Totten, where direct current motors can best be used, and the increasing number of steel cars is tending toward a greater use of metal working tools, which in general require direct current motors. The average shop will have direct current from forty to fifty per cent of the total power, and there have been cases where that was exceeded. On account of the low load factor and the necessity of operating alternating current motors at light load, the power factor of the railroad shop is low, in fact it has been as low as sixty per cent in some cases. In those cases the power factor correction can be obtained by a synchronous motor, which in turn would drive the motor for furnishing direct current.

"In cases where the power factor does not need specific correction, the direct current can be better obtained from a rotary converter. They have several advantages. The cost of the sixty cycle transformers and converters will in general be less than that of the synchronous generator set. Their weight will be less than the motor generator sets, requiring less expense for freight and handling. The full load efficiency of the rotary converters and transformers would be at least 5% better. At light loads the rotary converter would still be better, but not quite so much as 5%.

"In general, I would favor individual motor drive. There are a number of reasons for that which have been discussed more or less in the past, and I think it would be advisable to go over some of them again, because there still is a tendency to use group drive.

"In the first place it takes power to drive a line shaft and the power costs money whether you buy it from the central station or make it from coal. We have a test record of a shaft three inches in diameter driving twelve tools, the ordinary shop tools, and that is not an unusual line shaft for a number of railroad repair shops. The friction load of that shaft without any load on the tools was 6.3 k.w. and the average for the machine loads was 8 k.w., making a total of 14.3, and in this case the friction load was 44% of the total. As a line shaft running light would not have as much friction as that shaft loaded under side strains, the figure 44% is conservative.

"Other general advantages of the individual drive are that you can get better head room for the crane service and better lighting conditions on account of the elimination of the belting, and get more convenient arrangement of the tools with reference to handling of material. The tools in that case do not have to be located with regard to the shaft, but can be located at will. Belts which are liable to slip are the weakest element, and by eliminating the belt, more power can be supplied to the tool, with a consequently greater output.

"The speed adjusted with an individual drive is a simple matter. The type of motor can be selected which will hold the speed constant at any adjustment. By moving a controller handle, which can be located on the machine, the speed can be changed instantly. A given piece of work can be finished quicker with individual drive than with the mechanical drive. There is a saving in time in making the speed adjustments and adjusting the work. There is no slowing down of the tool on heavy loads due to belt slippage and the tool is not apt to be delayed by the accidents to other tools. There are often cases where the power to any machine is transmitted through three or four belts, with the chance of slippage in each belt.

"The saving in time is quite an item for the operator as well as the tool, and the time of the former is often not as valuable as that of the latter. A machine tool should be charged up with an equitable portion of the taxes, interest and depreciation on the buildings, the interest and depreciation on its own value, the repairs, renewals and salaries, general maintenance expenses etc., constituting what you might class as a machine hour rate.

"For large tools this may vary from 50c an hour to $5 an hour, which is considerably more than the time of the operator. You may assume that the lowest rate is 50c per hour and the operator is paid 35c an hour, making a total cost of operation of 85c an hour. As the tool will probably be under load approximately one-third of the time, due to the delays on account of changing the work and waiting for cranes, etc., the total cutting time of that tool is worth $1.50 an hour, making the total of

machine and operator $1.85 an hour. Now by installing the motor drive and with the savings and increased output, the output should be increased from 20% to 25% of that and would effect a saving on that tool of about 45c an hour,—more than enough to pay the operator.

"The uniform motion of motors permits their use in buildings that would not stand the jar and vibration of the long line shafts, which are seldom in good alignment. They may be so when installed, but they will not remain so. Therefore, if a new building is being put up, it would be a great deal cheaper to install individual drive because the building would not have to be as expensive on account of the elimination of line shaft, supports, etc.

"One of the biggest advantages of individual drive is the opportunity of checking up the record of a motor driving a tool. By the use of a graphic meter the performance can be accurately measured, entered and recorded. The meter will show just when the machine was started and when it was stopped and how long and under what loads it operated. It can be located in the foreman's office and circuits arranged so that it can be connected at will with any of the machines, and when such a record of a machine is being made, the meter will show delays in operation that might otherwise be unnoticed; delays such as undue delay in starting up in the morning, quitting before the regular quitting time, and operating machines at light loads.

Illumination of Railway Cars

A. J. SWEET

The president then called upon Mr. A. J. Sweet of the Nelite Works of the General Electric Co., to give a few remarks on the subject of "Illumination of Railway Cars."

Mr. Sweet said that the primary duty of an engineer is to harmonize more or less conflicting requirements. Engineering is largely a study of requirements and striking a proper balance between conflicting requirements. The question of determining the relative importance of various requirements is of highest importance.

Mr. Sweet said that he considered there were three major requirements in car lighting, as follows:

1. Comfort of Passenger.
2. Artistic Effect.
3. Efficiency.

These being in the order of their relative importance.

Mr. Sweet said that it was always necessary, however, to consider different classes of passenger service. In other words, in postal car service, efficiency might be the first requirement, while comfort of the men and artistic effect would be secondary. Considering the matter from a broad point of view, however, he said that he would consider the primary requirement to be the comfort of the passengers, both that of immediate ocular comfort and the comfort in avoiding eye fatigue.

Mr. Sweet differentiated between these two points, stating that immediate ocular discomfort is experienced when one looks directly at a light or is compelled to view objects with exposed lamps in the line of vision. Light sources of high intrinsic brilliancy always brings immediate ocular discomfort. One of the ways of avoiding this is to use diffusing bowls or shades. Matter of eye fatigue on the other hand is much more difficult to determine. In fact, the passenger does not always realize that his headache or depressed feeling is due to fatigue of the eye. As the knowledge of illumination becomes more and more disseminated, however, people will learn to recognize this point.

Eye fatigue is primarily caused by two factors; first the motion of the visualized object; second, light shining directly at the eye. All the light entering the eye not used for vision tends to reduce the efficiency of the eye. This reduction in eye efficiency may easily be as great as 50 per cent. even with light opal diffusing shades. Eye fatigue can be eliminated very largely by the use of opaque or nearly opaque reflectors.

Under the heading of efficiency, Mr. Sweet said that in car lighting we usually have to deal with dark head linings and a large percentage of window space which causes the maximum of illumination inefficiency. It, therefore, becomes necessary to have practically all of the light come directly from the light source or from the reflector used in connection with the lamp.

Mr. Sweet here pointed out, however, that the result of recent researches which he had conducted showed that light colored walls tend to reduce the efficiency of the eye, so that a large amount of window space and dark woodwork should not always be considered as an undesirable feature of the car. Light head linings, however, would undoubtedly improve the illumination efficiency without reducing the eye efficiency.

As to the matter of indirect lighting for railway cars, Mr. Sweet said that the present type of car construction is very unfavorable to this type of lighting. First of all, the head lining is comparatively dark, and, second, the center deck being so far above the quarter deck, a large amount of light from the indirect system will be absorbed by the ventilating sash. He said that the best type of indirect lighting which could be installed in the present type of car would not give more than 25 per cent. of the foot candle illumination that can be obtained from other systems of illumination. He said that possibly by improving the color of the head linings and making the ceiling the full arched type, we might get 40 per cent. of the illumination obtainable by the best direct lighting. The main advantage of the indirect system does not lie in the fact that the light source is concealed, but rather because of the fact that it gives a multiplicity of light sources. This greatly reduces the specular reflection of light from paper in books or magazines which are being read.

Mr. Sweet presented some interesting data on the illumination obtained with various types of reflectors as given below. These values are obtained from actual installation tests and are based on 8.3 watts per running foot with a bowl-shaped reflecting unit:

Clear prismatic reflector	3.1 f.c.
Satin finish prismatic reflector	2.5 f.c.
Best opal reflector	2.3 f.c.
Enclosing prismatic globe	2.3 f.c.
Light density opal reflector	2.0 f.c.
Opal bowl with enameled reflector	1.7 f.c.
Bare lamp	1.6 f.c.

Mr. Sweet placed the advertising value of the illumination in the car as one of the minor requirements. He said that this had often been made one of the major requirements, however, and long rows of bare lamps placed in a car evidently to impress the public with the

glare of the electric light. The education of the public, however, is improving this point so that the system which is now of good advertising value is one which is so because of its comfort and artistic beauty.

Artistic Possibilities in Car Lighting Fixtures

L. SKEPMOES

The illuminating engineer is chiefly concerned in getting the most efficient means for artificial illumination. His abilities are trained on the source of light and its proper distribution. The lamp manufacturers are interested principally in increasing the available light source and life of the lamps. The reflector manufacturer devotes his efforts toward meeting the illuminating engineers' requirements and incidentally toward selling his products. The fixture designer has to take what the illuminating engineer, the lamp manufacturer, the reflector manufacturer and his prospective client give him and then goes to it with the hope of producing something new, novel, cheap, efficient and artistic. Some specifications, by the way.

It is easy to make a fixture new and novel if you don't care how efficient or artistic it becomes. It is easy to make a fixture cheap without the other qualifications and it is sometimes easy to sell cheap fixtures once, but not twice. The efficiency of a fixture is easy to maintain if you have the co-operation of good illuminating and mechanical engineers, and use good lamps and reflectors. To combine mechanical and illuminating efficiency and originality with artistic effect in a cheap

Fig. 1. Four Light Center Fixture, As Usually Shown in Catalogs.

fixture is what sends the gray hairs and hollow eyes to the designer.

Probably not more than 25 per cent. of the time that the average passenger car is occupied is it necessary to have artificial light. It is, therefore, important to consider the appearance of a lighting fixture both when lighted and dead. We must admit that a fixture is more the center of composition in car design when lighted, than in daylight. The eye is always attracted to the brightest spots in a composition and for that reason we notice a fixture more at night than in daylight.

The appearance of a fixture undergoes a radical change when lighted. The fixture is viewed as a mass in daylight. Its lines and proportions must be pleasing. The color of the glass must blend harmoniously with the color of the balance of the fixture and it must scale nicely with the area and finish of the car interior. The color finish of the metal portions of the fixture should harmonize with the color treatment of the entire car. A fixture might have the most pleasing effect in daylight and at night, when lighted, might present a decid-

Fig. 2. Same As Usually Viewed By Passenger.

edly unpleasant appearance. This is due to the fact that at night we do not receive an impression of the fixture in its entirety as in daylight, but our eye follows only the line of the brilliantly lighted portion; that is, the lighted glassware.

The same change occurs in any indirect lighting fixture in a somewhat different way, inasmuch as the portions of the fixture above the source of light are more emphasized at night than in daylight. I mention this changed appearance of a fixture since it should be carefully considered by the fixture designer and those empowered to select car lighting fixtures.

Before considering different types of lighting fixtures I would like to say a few words about metal color finishes and the ornamentation of fixtures. There seems to exist an almost universal desire among car builders and railway men who have anything to do with fixtures to have every fixture match every other fixture exactly as far as color is concerned. Why this condition exists it is hard to understand. An architect or a skilled decorator would not consider such a monotonous color effect. He would want the same general basic color employed but the color tone variations possible in brass and bronze finishes are the delight of a decorator. Why is mahogany so beautiful? Isn't it because of the wonderful gradations of tone given by the graining? To my mind it is a mistake to insist upon having every fixture colored in a mechanical monotone without any regard for the artistic appearance. Simply because

some inspector is given a little sample plate about an inch square as a guide to inspect the finish of the fixture, he stupidly insists on having every particle of the metal portion of the fixture made to match his sample.

Fig. 3. A Well Proportioned Center Deck Fixture.

This question is not raised because it is easier to apply variable tones to the color finish of a fixture; it is much easier to give a workman a sample and insist on his matching his color to it. Some day an appreciative railway man is going to pass judgment on his fixtures and maybe we will have a real demonstration of artistic color finish on the fixtures of a railway car.

Ornamentation is like tobasco sauce,—it should be served sparingly. When you look at a drawing or design of a proposed lighting fixture you should use a reducing glass and not a microscope. Consider first the profile of the fixture; judge whether or not it has pleasing lines and whether it is well proportioned to give a good effect in the car for which it is intended. Don't judge the entire fixture by a little spot of detail. If you don't like it, have it removed entirely rather than changing the shape of a little leaf about one-quarter of an inch wide. Over ornamentation has killed many an otherwise well proportioned design. Remember one thing when considering ornamentation; it is a poor artisan who always employs ornamentation to cover up poor workmanship. Ornamentation may look all right on a drawing when you need it to make a filler in order to comprehend the profile or mass of the fixture, but it is lost in a car and often looks like putty stuck on the pattern.

Now let us consider for a few minutes some different types of fixtures used in car lighting. I will first make the statement that center deck lighting is preferable to half deck lighting. Both of these systems have their champions, but I think the weight of opinion is in favor of the former. Sentiment and custom undoubtedly prejudice some minds, but we can consider the matter intelligently from certain knowledge of definite facts. Center deck lighting is the oldest and most extensively used and for that reason sentiment is probably in its favor. When we are accustomed to see fixtures located in the center deck of a car it is like knocking the spire off a church to leave the center deck bare and place all the fixtures along the half deck of the car. We will try to forget any of these sentimental reasons and treat the matter from a somewhat logical standpoint. Let us consider the two methods in relation to the illumination available; the avoidance of glare, the shadow effect, general appearance and economy.

I think Mr. Sweet or any other man present, who has made an exhaustive study of car lighting, will confirm me in the statement that the best types of center deck lighting installations are capable of giving uniform illumination at the aisle and window seats, equally as good as the best half deck installations. Therefore, we can say that center deck lighting is equally as good as half deck lighting in so far as the general principle of illumination is concerned.

Glare is undoubtedly the most objectionable feature of artificial illumination due to its effect in producing eye fatigue. You cannot totally avoid glare in a railway car. It is present to a marked degree even in daylight illumination. The passenger occupying the first seat and facing the front end of a coach does not get much glare from the lighting fixtures, but we must not consider any one or two positions for comparative results. We must take the car as a whole and consider the average condition. If we consider the same type of fixtures located on the center deck and along the half deck the glare from the latter will be more objectionable than from the former, since more of the lights are within the passengers' normal range of vision. Therefore, the avoidance of glare is a point in favor of center deck lighting.

Fig. 4. A Graceful 4-Arm Combination Fixture.

In considering shadows we must make two classifications,—the shadow thrown by the passenger on the paper and the shadows created by the car design. Center deck lighting is often objected to on the ground that the

deck rail makes an ugly shadow along each side of the car. Personally I do not object to this shadow unless it is too dark and not softened by a certain amount of reflected light. I have seen but few shadows created by center deck lighting that were ugly, and the entire absence of a shadow in a car or any other place is not pleasing to me since we depend on shades and shadows to realize from. The shadows on the paper or book are possibly more objectionable in center deck lighting than in half deck lighting, providing the lamps on the deck are located at every seat, which is very unusual. Where the lights are located at every other seat along the deck rail I think the shadow effects are about equal to those produced by center deck lighting. Occupants of passenger car seats invariably adjust their positions to avoid shadows on the paper with any system of lighting, and

Fig. 5. An Artistic Bowl-Unit Type Center Fixture.

are almost unconscious of this condition so we can probably consider the shadow question as favoring neither system.

The comparative appearance of center deck lighting and half deck lighting is undoubtedly open to discussion. I will throw the weight of whatever opinions I have in favor of center deck lighting. You cannot place fixtures along the half deck without creating a crowded appearance and you also create on optical effect of reducing the height of the car interior. It is the same principle that vertical lines in wearing apparel make a person appear taller and vice versa. The center deck of a car offers the most logical place for fixtures while the lines of the half deck are interrupted and destroyed by fixtures. You must have center points in any composition, to make it attractive and the rule is applicable to a car interior. Rows of windows, deck sash and seats need something to break their monotony and nothing does it so admirably as properly designed lighting fixtures located on the center deck.

Regarding the economy of these two systems there is a preponderance of weight in favor of center deck lighting. Initial cost and cost of maintenance are both higher in the half deck systems and I do not need to dwell on figures to emphasize this point.

With the argument in my mind decidedly in favor of center deck lighting I will now ask you to refer to the illustrations while I conclude my remarks. I have illustrated five distinct types of center fixtures. For the sake of comparing these different types let us assume that they are all equally efficient from an illuminating standpoint. The tests to be made at Washington

Fig. 6. Same, as Usually Viewed In a Car.

will undoubtedly establish their respective illuminating merits. All that I desire to say at this time will be confined to giving opinions regarding their artistic appearance.

Figs. 1 and 2 show a four-light center fixture. I have purposely given two views of this fixture to better illustrate the appearance. I will not say that this particular fixture marks the height of artistic excellence for this style of fixture. It can be improved artistically, but at its best it falls far short of having any real artistic merit. There is no composition to its mass, its profile

Fig. 7. A New Diffusing Bowl Fixture

is devoid of any real graceful lines, and its type is to my mind the least attractive of the five general types of center fixtures, I have illustrated. Quantities of this general type of fixture are in service and will be sold but I am endeavoring to treat this subject strictly without regard to commercialism. Please note that Fig. 1 shows a view of the fixture as you usually see it illustrated in catalogues and from which you often select your lighting fixtures, while Fig. 2 is about an average of the views you would get of this fixture in a car. You will readily agree that it does not improve its apppearance, but loses in perspective.

Fig. 3 shows the most acceptable type of single unit center deck fixtures with the open mouth reflector. We are now getting some graceful lines in our profile and the glass and metal portions of the fixture are nicely

proportioned. This general type of fixture does not improve in perspective and in that respect is like Fig. 1, but is far preferable to Fig. 1, and also preferable to the single unit open mouth reflector fixture where a small frail-looking stem is used between the ceiling base and glass portion of the fixture.

Fig. 4 illustrates a four-arm graceful combination gas and electric fixture. This general type is best illustrated by this particular fixture. It does not materially lose its attractiveness in perspective, and if you will now please refer to Figs. 5 and 6, the point I will make will be more clearly understood. You will note that both these types of fixtures use an enclosing bowl, and that the appearance is about equally good, viewed from any angle. This leads to the conclusion that the most ideal types of fixtures considered in regard to appearance are those using a bowl. The four-arm combination fixture has much in its favor artistically. Long graceful lines well proportioned with the body of the fixture and this particular fixture presents a very attractive effect when located in a railway car.

My personal preference in selecting any of the types illustrated would be either No. 5 or No. 7. Both of these are admirably adapted to meet the aesthetic tastes. Any car would be improved in appearance by the use of either of these fixtures and everything else being equal I don't think anyone would regret the selection of these fixtures to light a car whether it be a passenger coach or a private car. Both of the last mentioned fixtures might be considered too ornate for the average passenger coach and undoubtedly No. 3 would prove the most acceptable for this class of service.

I have not made any particular reference to indirect lighting. This method of car illumination is receiving serious consideration and aside from its handicaps in the matter of light colored ceilings and increased wattage, offers many attractions artistically. One point that has not received deserved attention is the optical effect of high ceilings produced by this method. Any style of interior decoration or any system of illumination that can help to destroy the feeling of low ceilings deserves consideration from railway men.

Methods of Axle Generator Control

W. L. BLISS

I think it is a fundamental proposition in axle lighting control that we do not want constant current regulation and we do not want constant potential regulation, and all attempts to produce either of those effects to the exclusion of the other, would be absolute failures. We have heard it said a good many times that the constant speed generator could be driven from the car axle and give perfect constant potential. That problem could be worked out, but it would be going back to the beginning of things. The constant potential generator on a car would be absolutely useless so far as I can see, if operated in connection with the storage battery, for that potential would not charge the battery.

Now it seems to me that the very fact that we have the variable speed on a railroad car is most fortunate in connection with the lighting of railroad cars from the axle in connection with storage batteries. The variation in speed gives us a chance to change the voltage and it is only a question of taking advantage of that natural change in voltage that good results would be obtained. The fact that speed variation is quite considerable, in percentage, of course, introduces another element which must be provided for. If our speed variation in the railroad train service was only a small percentage, we could probably get along without very much regulation and have just the effect that is wanted. I think that the ideal system of regulation is one that permits the generator to deliver its full capacity, for as much of the available time as possible. That means that you are not carrying a dead investment or unnecessary dead weight.

On the other hand, I think it is desirable to protect the storage battery, and this is certainly an important factor. Everything possible should be done toward applying a regulating system which will protect the storage battery.

These two conditions are somewhat conflicting and some middle course will have to be pursued. As Mr. Sweet has said, the business of the engineer is principally to adjust conflicting conditions. Now it might be highly desirable to arrange a system of regulation practically and simply for the benefit of storage batteries. Such a system then would deliver current to the storage battery in precisely the same manner the manufacturer of that battery might prescribe. That might not be the most economical thing for the railroad man to do, however, and it might not result in the best possible lighting of the car, taking every question into consideration. We have a balance to strike there, in the form of a compromise, and I do not believe that good judgment warrants us in giving all our attention to the treatment of the storage battery. I think that we can very safely devote maybe eighty per cent of our energies to that line, but I do not believe that we should devote all of them. Now that brings us to the conclusion, it seems to me, that what we want is primarily a system of regulation that will limit the output of the generator, so that the generator can be designed and built for that output and work economically under it. Such a system naturally suggests a constant current method of control for the generator.

Now the output of the generator must necessarily be dependent upon the variation of speed, and naturally at higher speeds we can get a higher output than at lower speeds. At that we should arrange the apparatus in some manner that, at as low a speed as is consistent, we can obtain the maximum output of the generator and then from that point on hold that current as nearly constant as it is possible to do, so that the generator will be working under substantially full load and with economy.

The current having been so regulated, we of course know that it divided between the storage batteries and the lamps, and it is up to the man who lays out the lighting in the car and specifies the size of the battery to say how this division is going to be arranged or effected. I think that most of us will agree that the size of the generator and its capacity should be such that no matter what service the car might be placed in, (we all know the way cars are thrown around in railroad service), sufficient energy would be generated by the dynamo to absolutely insure that the battery will always be charged, and that means that the generator must be of large enough capacity to take care of the battery under the worst conditions, and that also means that under the most favorable conditions the battery would not be

greatly over-charged, but in order to avoid the necessity of adjusting the output of the generator every time the number of the train changes, it seems to me that it is necessary to provide that the generator shall be capable of keeping the batteries fully charged under the worst circumstances. That leads, of course, to the question of preventing storage battery overcharging.

Of course, if the arrangement is such that the batteries never do get overcharged, no stop charge device is necessary; in that case, however, it will always be found that the batteries are under-charged, because it is an impossibility to arrange any system that the charging and the discharging will be in such proportion that the battery will be in just the same condition that it started in at the beginning of the year. That is impossible.

Now various suggestions have been made and a good deal of labor has been performed in attempting to provide means for the prevention of over-charging the storage battery. Briefly stated over-charging is prevented by discontinuing the charging current when it has been running long enough. What condition shall determine this is somewhat hard to say. There are a good many conditions that might be employed to determine when the storage battery is fully charged, but I doubt if anything but a test will tell when any storage battery is fully charged. We have, however, certain simple conditions that are a fair indication of the condition of complete charge.

It might even be stated that some device, responsive to changes in gravity could be used, selecting one cell as a representative of the whole set. It has been suggested that some kind of a device responsive to cadmium readings could be worked up, again requiring that only a single cell be used, because this kind of measurement cannot be made in bulk. The only measurements that can be made on a multiplicity of cells in bulk, are such kinds as ampere hours, watt hours, current and voltage, things that are connected with the whole series of cells.

Now of those four kinds and one other which is not difficult, that is time, which are you going to take? You can take the voltage as an indication; you might take the time and watts, which results in watt hours, and instruments can be devised which are responsive to those indications.

To stop the charging process when those conditions obtain, so far as simplicity is concerned, there does not seem to be anything quite as easy to apply as something that is responsive to voltage. If you undertake to drag in the element of time, it means some kind of integrating apparatus. I believe that a very successful apparatus of this kind has been made by the Sangomo Electric Company. It is quite conceivable that an apparatus can be made which can indicate the number of ampere hours that have gone into the meter and stop the charging. This is all simple enough, but it is more or less involved and a little bit complicated and does not take care of the conditions. It seems to be that a voltage device is quick to operate, does not involve any integrating apparatus, and has the additional advantageous feature of being able to protect the system against such accidents as open battery circuits, etc., which an integrating device cannot very readily do.

It therefore comes down to a question of some voltage device acting at the proper time when a certain voltage has been obtained, to start in motion certain instrumentalities to stop the charging process. Now there are no end of devices of this character which can be made, but all of them will, I believe, be found ultimately to be connected with the generator, and all will be found ultimately to be directed towards affecting the generator field, as that is the simplest and most easy part of the generator to attack. The question would then naturally arise after having selected some voltage operating device for reducing the effectiveness of the generator, as to just how we want this device to affect the generator. Shall the generator be completely put out of commission and kept out of commission until the storage battery has been discharged, and then the generator automatically brought back into commission again, or shall we undertake to kill the generator to a certain point, not necessarily completely, but to a certain point where its usefullness is still more or less apparent and where it can still furnish current for other devices from which we do not wish to stop the flow of current? Then the question as to whether or not we want to let the charging current taper off to some lower value, and how long we shall want this taper to continue, or whether we shall want it a steep taper or a long drawn out taper, etc.

It seems to me that the best proposition is to arrange the device in such a manner that the charging current shall bring the battery current suddenly to zero, because the small current charges which result from these other methods are injurious to Plante' batteries, which is the type almost universally used in car lighting. I do not think that with a pasted battery it would matter very much, but it certainly does have a bad effect on a Plante' type as it forms away the reserve lead of the element until the strength of the plate is pretty well used up, the entire mass then can no longer hold together and falls down to the bottom of the jar. Therefore I think that the consensus of opinion today is that we should stop the charge of the battery.

Now what to do with the generator after that point is the question, and I think that the ideal method of treating the generator is to reduce the generator voltage to a lower point immediately after the operation of what we will call our charge stopping device, and then maintain the generating system as a constant potential system, but at this lower voltage. If this can be successfully accomplished, and the generator be made to hold that voltage irrespective of changes, the current flowing to the battery will be zero and the generator will be in condition to take up any load that may be put upon it, such as lamps or other devices, and we will not be calling upon the battery to discharge, yet we can hold the battery at such a position that it cannot charge. That would be the ideal scheme. I have worked along those lines myself and have also endeavored to produce results of that nature.

Such a device when made has the advantage that it will work through an open battery circuit, because if the arrangement is such that the battery can be floated at zero current, it does not matter whether the battery circuit is open or not. Consequently a device of that kind ought to be perfectly stable, and the danger of blowing out the apparatus when the battery circuit is open will then be eliminated.

Briefly stated, therefore, without going into any degree of description of special means for accomplishing this, I think that so far as my own judgment and experience is concerned, I would say that the ideal generator regulation consists in providing first, the means for giving constant current from the generator with a very sharp knee in the curve when this curve is plotted with the constant speed. The next point that should be given consideration is that as soon as the voltage has reached the point selected, the generator voltage shall be immediately reduced to floating voltage, and there maintained.

When that has been accomplished, I think that the question as to method of generator regulation has been answered."

Mr. T. L. Mount of the Consolidated Ry. Elec. Ltg. & Equip. Co., was then called upon for a few remarks on the subject, but said that he thoroughly agreed with what Mr. Bliss said and hoped that all members not present would read over very carefully Mr. Bliss' talk as published in the *Railway Electrical Engineer*.

Mr. Wray of the *Railway Electrical Engineer*, said he hardly agreed with Mr. Bliss as to the advisability of floating the battery after a certain definite voltage had been obtained, as this principle seems to have all the inherent disadvantages of the stop charge relay principle. He said it is a well known fact that the voltage of the battery is no criterion of its condition of charge; it does however, give a qualitative indication as to the battery condition if properly handled. Operation of the past five years has shown that battery voltage when applied as a stop charge principle is unreliable and fundamentally wrong. A battery which is slightly sulphated will give a higher voltage than normal, so will reach the cut off voltage value before it is fully charged. This undercharging results in further sulphation and a more abnormally high voltage on the next charge. In other words, a battery partly sulphated may very easily go from bad to worse when operated in connection with a stop charge relay. On the other hand if the battery is very warm and plates are not sulphated the full overcharging voltage may never reach the point of cut off. Then as the battery continues overcharging this voltage will actually fall away from the cut off value instead of rising further. The plate destruction caused by this overcharging are high temperatures is too well known to require further comment.

Mr. Wray maintained that the principle advocated by Mr. Bliss of cutting off battery charge at a certain predetermined value of battery voltage and floating the battery thereafter was not essentially different in principle from the stop charge relay method of control.

He further pointed out however, that this was not any objection to any particular type of equipment for any of the standard voltage devices could easily be adjusted to float at a voltage high enough to provide a charging current of low value even after cut off voltage was reached.

He said that this low current flow just at the finish of charge was highly beneficial to the battery in compensating for any inaccuracy due to a low setting of the stop charge relay.

He said that the ampere hour meter seemed to offer a most plausible solution to the problem and although up to the present time this meter had not been applicable to axle lighting service, as a controlling device, recent developments have made this practical.

Mr. Hulse, of the Safety Car Htg. & Ltg. Co., continued the discussion stating that it was their policy to have the regulator limit the current output to the rated output of the generator, and also to the rated initial charging rate of the battery, and at the same time keep the generator voltage from exceeding a certain maximum value.

Mr. Bliss continued the discussion and said that it was an almost impossible proposition to tell by any simple means whether or not a storage battery is fully charged.

"It would require an examination being made by an expert of every cell in the battery, and he would have to measure the voltage and probably take the plates out and look at them before he could tell what condition they were in. It would be simply impossible to make any kind of automatic apparatus that would tell all those things; it would be a good bit like trying to make a mechanical servant girl.

"Now it might be a good proposition to perhaps combine an integrating device with some device which operates on voltage, if those two devices could only arrange it between them so that one of them always acted first and properly, I think that something would be still further accomplished, but there certainly would be times when the integrating device should speak first and times when the voltage device would speak first. That would then lead to another device that would settle the difficuly.

"I think, though, that what Mr. Wray says in regard to sulphation of batteries was a great deal oftener the case in the old days then it is at the present time. I think that in the old days, when the generators fell down, that the trouble with sulphation on account of great and frequent overdischarging, was very prevalent, but I am of the opinion from what I have been told, that quite the opposite condition obtains today. More batteries are damaged by being formed away than there are by being sulphated.

"This might be a pretty good subject for the battery committee to get into and find out which of those two causes is giving the most trouble, overcharging or undercharging, and that would perhaps be a tip to the car lighting engineer to have something made that would take care of the worst conditions. He could not make anything, I am pretty sure, that would take care of both overcharging and undercharging. However, I think that today the opinion is that more batteries are injured from overcharging, which means over formation, and consequently I would work along this line. If it be true that the ampere hour charging into the battery is the best indication, I think that a device of that kind would be adopted. I am of the opinion that one of the best things the organization can do would be to determine that point and let us know which way we ought to make the apparatus to do the most good."

Mr. Frost said in closing the discussion, that one of the most serious matters in the charging of storage batteries is the heating on charge. As long as the battery does not heat and does not grow, there is little trouble liable to appear.

He then said, on account of the lateness of the hour, it would be impossible to take up the subject of "The Haulage of Electric Equipment" which had been scheduled; and after a final word to the committee men, urging them to serious and effective work during the remaining months preceding the Annual Convention, the meeting adjourned.

CONVENTION EXHIBITS

The following gives an idea of some of the exhibits which were of interest to electrical men.

The Consolidated Railway Electric Lighting & Equipment Co., showed their new regulator and new generator. These will be described in the August issue of the *Railway Electrical Engineer*. They also exhibited the new spring belt fastener; this, too, is to be described in the August issue. P. Kennedy, Thos. L. Mount, J. L. Watson, L. J. Kennedy represented the company at the Convention.

Gould Coupler Company showed their new locker panel containing both lamp regulator, machine regulator and individual lamp circuit switch. Extra long dash pots are supplied on the new regulators. On the new boards a strip of iron is fastened permanently to the back of the board and passes in a zig-zag manner so as to cover

all of the tap holes for fastening the regulator parts in place. This is drilled and each hole threaded so that it takes the place of the nuts on the back of the board and makes it unnecessary to do any work whatever behind the board. All circuit connections are made of heavy taped stripped copper permanently installed.

There was a new feature shown in connection with mounting an armature on the shaft. An upset portion of the shaft being machined into triangular form fits exactly into a recess of similar form in the armature core and three screws hold the armature tightly in place. A small key and keyway is provided merely as a guide in putting the armature on the shaft. This, however, in no way takes part in driving of the armature. The armature is of a single turn per coil type and single turn per slot. A complete line of Gould train lighting batteries and battery parts were on exhibition.

George Milne, G. R. Berger, M. R. Shedd and W. T. Sherman, were in attendance at the Convention.

Safety Car Heating and Lighting Co. The new Safety voltage current regulator as described in the June issue of the *Railway Electrical Engineer* was on exhibit, but what impressed one on entering their booth was the complete line of car lighting fixtures both for gas, electric, and combination gas and electric. A number of these are shown in connection with paper presented by Mr. L. Schepmoes and published in this issue.

One of the new type ball bearing generators conforming to the recommendations of the committee on Ball Bearings was shown.

The company was represented by A. C. Moore, J. G. Van Winkle, G. E. Hulse, C. B. Adams, E. I. Pollock, L. Schepmoes, J. S. Henry, G. F. Chadwell, W. L. Garland, L. Everett, M. F. Elliott.

U. S. Light and Heating Co. A big white roadster almost filled the U. S. booth, but when you got inside the booth and examined it closely, it was found to carry miniature U. S. car lighting system complete, and this furnished power for lighting, ignition and starting. The armature is in the form of a hollow ring mounted directly on the crank shaft with the generator fields mounted stationary inside of it. The armature then takes the place of the fly wheel, and being of extra large diameter gives a heavy torque in starting.

Their new current-voltage controlling panel to be described in the August issue was also shown, and one of the new type ball bearing generators and a full line of "National" car lighting batteries and parts were on exhibit. A big sign, "6000 Equipments in Service," looked mighty impressive and did its own talking.

The company was represented at the convention by D. W. Pye, J. Allan Smith, W. L. Bliss, A. Russell, W. P. Hawley, C. C. Bradford, W. A. Turbane, W. F. Bauer, C. L. Lane.

Edison Storage Battery Co., showed all the various types of Edison cells for railway car lighting, signal and power service.

One of the features of the booth was a big A.12 500 ampere hour cell which was short circuited to exhaustion every afternoon. The current flow in this short circuit started at about 1500 amperes and gradually tapered to zero at the finish of discharge.

An ammeter with a scale of 0 to 1500 was mounted on a small board together with a very heavy short-circuiting switch with 1,000,000 c.m. cable connections. H. G. Thompson was in charge of the exhibition.

Electric Storage Battery Co. showed the Pennsylvania and Santa Fe standard car lighting cells, also had a four cell tray of 29 M.V., 420 ampere hour cells of the type used in Third Avenue Railroad in New York. A new type hydrometer syringe 10 in. long, (type S.) was also shown, this being considerably smaller than the hydrometer syringe formerly made.

They also showed a new car lighting cell, a 21 plate element, consisting of Exide positive and Shelf negative. This battery has a capacity of 560 ampere hours yet goes into a standard 350 ampere hour tank, this being the maximum size which can be gotten into the standard type battery boxes. Mr. H. E. Hunt was in charge of the exhibit.

Booth of the U. S. Light & Heating Co.

Nelite Works of the General Electric Co., showed a beautiful line of new car lighting glassware. Among the lines of prismatic glassware shown, was the hexagonal unit with bottom hexagonal prism plate as described in the May issue of the *Railway Electrical Engineer*.

They also exhibited a new iris shade which had a pearly white luster by daylight, but by night illumination showed some artistic redish brown lines, which gave a very attractive appearance. The glassware being of a very dense opal, the reflecting efficiency of the unit is high, This type of reflector was of the type made specially for the new Santa Fe cars.

They also showed a full line of enameled steel and aluminum steel reflectors for baggage and mail cars, as well as their standard line of prismatic reflectors for general purposes. Mr. A. J. Sweet and L. C. Doanne, had charge of the booth.

General Electric Co., exhibited a very complete line of electrical appliances as used in railway service. This included a mercury arc rectifier; flow meters for measuring steam, air or water; graphic recording and indicating instruments, portable air compressor, and a complete line of machine tool motor controllers. The latest type railway motor with forced ventilation directly through the armature making passible to use a much smaller motor than formerly was on exhibition.

They also showed their new reversing planer type motor and controller as described in the June issue of the *Railway Electrical Engineer*, and a very complete line of drawn wire filament lamps for train lighting and general use; a battery truck crane and an electrical headlight was also on exhibition. L. W. Sugg was in charge of the exhibition but A. I. Totten and numerous other salesmen were on the job.

Electric Controller and Mfg. Co. had a big lifting magnet in actual operation hoisting heavy iron castings and miscellaneous iron parts transferring them from one pile to another.

They also showed an operating exhibit of their break-

ing dynamic controller and their reversing dynamic breaking controller for bringing a motor quickly to a stop.

A complete line of automatic motor starters from ¼ h.p. up, a new type B overload circuit breaker and a miscellaneous assortment of hand rheostats were on exhibition.

Railway Utility Co. had a very interesting exhibit which was of special interest to electrical men, as it contained many new and interesting devices. A new steam hose coupler and vacuum cleaner, both described in the June issue of the *Railway Electrical Engineer*, were exhibited.

A new heat regulating system for steam heat, furnace heat or electrical heat was also shown. This operated on the principle of an electric contact being made within a thermometer. This contact carries a slight amount of current, sufficient to control a solenoid which either shuts off the steam line valve, opens the furnace damper or turns on or off the electric heating circuit as required.

They also showed an individual berth air washer which consisted essentially of a small box of water to be set just outside of the window with a funnel arrangement to catch the air and force it through the water into the berth. The sleeping passenger will then be provided with clean cool washed air at all times when the train is moving.

They also exhibited a new type lamp jack for gas or oil lamps, a freight car door fastener and a new type of stock and tool cabinet units for the store room. Mr. W. J. Pine, L. T. Hines, and C. A. Luckey, represented the company at the Convention.

Chicago Pneumatic Tool Co., showed their three phase indication motor drill, universal type, which would work either on A. C. or D. C., and a precision lathe grinder for the finest work in grinding shafts to a high degree of accuracy.

H. W. Johns-Manville Co. showed their fiber conduit, ebony asbestos wood for switchboards and car circuit pannels, Linolite lamps and a complete line of Noark fuses. J. E. Meek was in charge of the exhibit.

Burton W. Mudge Co. exhibited their new type Garland ventilators for arch roof type cars. This ventilator employs the same principle of air exhaust that the original Garland ventilator did, but is mounted directly on top of the roof and exhausts from ports located in the center of the arched ceiling. They also exhibited a new monitor roof type ventilator.

Remy Electric Co. had an operating headlight turbine on exhibition and also showed another turbine with parts cut away so as to clearly demonstrate the mechanism of both turbine element, valve governor and dynamo parts.

They also showed their new headlight case with both arc and incandescent lamps, either of which can be employed at the will of the engineer by simply turning a switch.

Pyle National Electric Headlight Co., exhibited their new type electric headlight.

American Pulley Co. exhibited their pulleys for axle car lighting in both the flange and flangeless type.

They also showed their new tapered steel bushing with wrought iron clamps.

The Main Belting Co. exhibited their new type of Leviathan belt which has been specially designed to meet the severe conditions of car lighting service.

Westinghouse Elec. & Mfg. Co. had reserved one of the big spaces fronting on the ball room and concert hall. Although they had no exhibit of appliances whatever, their booth was a popular place, especially in the evening during the informal dances.

The Westinghouse Lamp Co. was represented by Mr. B. F. Fisher and A. J. Cole, while Mr. R. E. Geare, well known to railroad men in the West, was one of the representatives of the Westinghouse Elec. & Mfg. Co.

LESSON NO. VI.

The Edison Battery

Having devoted the last three lessons to the lead storage battery, we will now take up the new Edison battery which has recently been developed for car lighting service.

This battery is radically different from any of the lead types in that the action which goes on inside the battery is merely the oxidation and reduction of metals in an electrolyte which does not combine with either oxides or metals in the battery. Since there is no combination of the electrolyte with the active material as in the case of the lead battery, there is no change in the gravity of the electrolyte during charge or discharge.

The active material of the positive plate consists of nickel hydrate while in the negative plate it is iron oxide. The electrolyte is a solution of potassium hydrate (21%) to which has been added a very small percentage of lithium hydrate. The normal specific gravity of the electrolyte is about 1.200. This, however, may fall as low as 1.150 or get as high as 1.250 without seriously affecting either the battery capacity or efficiency.

The positive plate, as shown in Fig. 1, is made up of a number of small tubes which are filled alternately with nickel hydrate and flake nickel in layers, as shown in Fig. 4. This flake nickel is an interesting and very important part of the battery. It is formed by plating very thin layers alternately of copper and nickel until a composite sheet about .01" is formed, consisting of 250 lyers of nickel and copper alternately deposited. This sheet is then cut up into tiny squares about 1-16 of an inch on a side and placed in a bath which dissolves out the copper and leaves the very thin flakes of nickel intact. This mass of nickel flake is then washed free from copper and solution, and when it is dried is about as light as, and looks very much like, a heap of snow.

An idea of the structure within a positive plate can best be obtained by microscopic examination as shown in Fig. 7, which shows a magnified section of a standard tube which has been sawed lengthwise. The vertical walls are the edges of the perforated metal containing

tube; the white thick layers are nickel hydrate and the dark thin layers are flake nickel. It should be noted that these thin layers of nickel which are formed in loading the tube alternately with nickel hydrate and

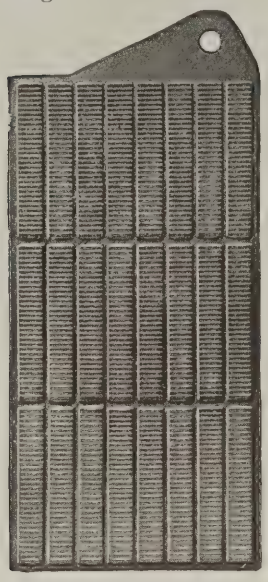


Fig. 1. Negative Plate.

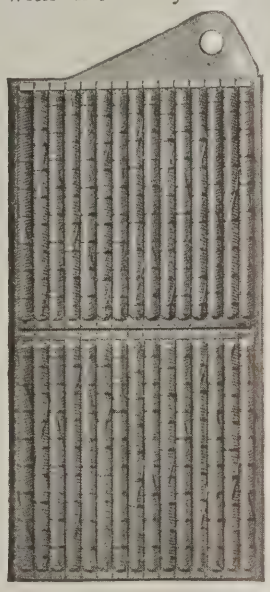


Fig. 2. Positive Plate.

nickel flake, extend practically unbroken across the tube, and both make good contact with metal walls of the tube, and at the same time conform to the irregularities of the nickel hydrate layers. These metal layers conduct the current to or from the nickel hydrate in all parts of the tube very effectively. There are about 300 layers of each kind of material in a tube 4⅛ inches long.

Fig. 3. Negative Pocket.

Fig. 4. Positive Tube.

The positive tubes are flatened at the ends as shown in Fig. 4, and the frame is slit at the inner horizontal edges and then folded in such a way as to make individual clamping jaws over the flat ends of the tubes. This clamping is done under tremendous pressure, so the plate formed has great rigidity and strength.

Fig. 5. Complete Cell.

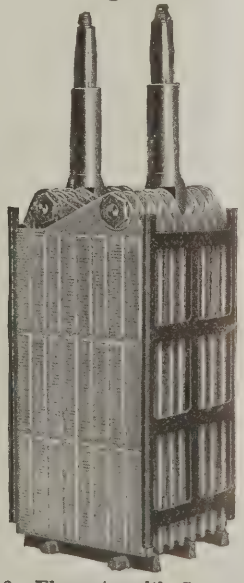


Fig. 6. Elements with Separators.

These perforated tubes are made from a nickel plated strip of steel spirally wound into the form af a tube with a special interlapping joint where the edges of the strip join. These tubes are reinforced with seamless bands as shown in Fig. 4, so as to prevent excessive expansion of the active material within, which would have a tendency to loosen its electrical contact with the tube.

The negative or iron plate, Fig. 1, contains flat pocket-

Fig. 7. Magnified Section of Positive Tube.

like sections which are also brought into a good electrical contact with grid and made rigid by hydraulic pressure of 160 tons.

The plates are assembled on a horizontal steel rod which is an integral part of the battery terminal post. They are held apart on the connecting rods by nickel-plated steel spacing washers and are firmly held in place by nuts screwed on both ends of the rod. As is the usual practice in battery construction the two outside plates are negative. These are insulated from the containing can by sheets of hard rubber as shown in Fig. 6. Pieces of hard rubber are also set between the can and the side edges of the plates. These together with hard rubber rods inserted between the plates maintain correct spacing and insure permanent insulation. A hard rubber rack or bridge supports the elements at the bottom of the can.

The cover of the cell, which is welded in place, has three mountings. Two of these are for stuffing boxes through which the positive and negative poles extend; the other is a combination gas vent and filling opening. This consists of a cap from which is hung a hemispherical section of hard rubber, which rests upon a suitable seat when the cap is closed, allowing the gases to freely escape, yet preventing the entrance of air and foreign matter of all kinds. It also acts as a separator thus minimizing the weakening of the electrolyte due to gassing. The cap is fitted with a double acting spring which holds it either open or closed. Allowance is made for about 3 inches of electrolyte above the tops of the plates,

so that it will not be necessary to flush the cells as often as in past practice.

The cells are essembled in wooden trays, usually three cells per tray, as shown in Fig. 9. Pressed steel cradles, one for each cell, are suspended from the sides of the tray and the flange on the bottom of each cell fits into a groove in the cradle. A pressed steel "holdown" at the top of the cell keeps it rigidly in position. These trays are designed to fit standard size battery boxes on railway cars and are provided with skids for sliding in and out of the battery compartments.

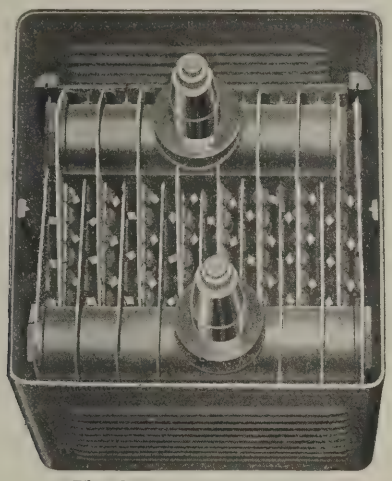


Fig. 8. Elements in Can.

The terminal posts are tapered slightly and the connector lugs having a similar taper are fastened securely in place by a nut which screws onto the threaded tip of the post. The connectors between cells are short copper rods, swedged into the lug forgings. These connectors, of course, are made in various lengths so as to accommodate the various cell spacings required. To disconnect the cells a small hand jack is provided, with which the lugs can be quickly drawn off the tapered terminal posts. No soldered or burned connections are made.

For convenience in flushing or filling cells a special

Fig. 9. 3-Cell Tray.

filler has been designed which rings a bell when the proper level of solution is obtained.

All parts of the Edison battery are nickel-plated, the nickel being plated directly upon the steel. The plated parts are placed in an atmosphere of hydrogen and heated to a very high temperature, which causes the thin plate of nickel to partially fuse into the surface of the steel.

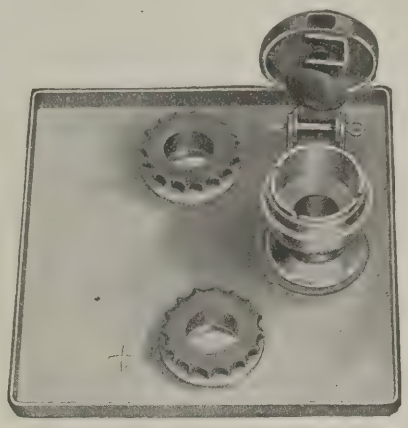


Fig. 10. With Gas Vent Open.

Operation.

The average discharge voltage is 1.24 volts per cell, at the 8 hour rate of discharge; so that for a 30 volt equipment the number of cells required is 25, and for

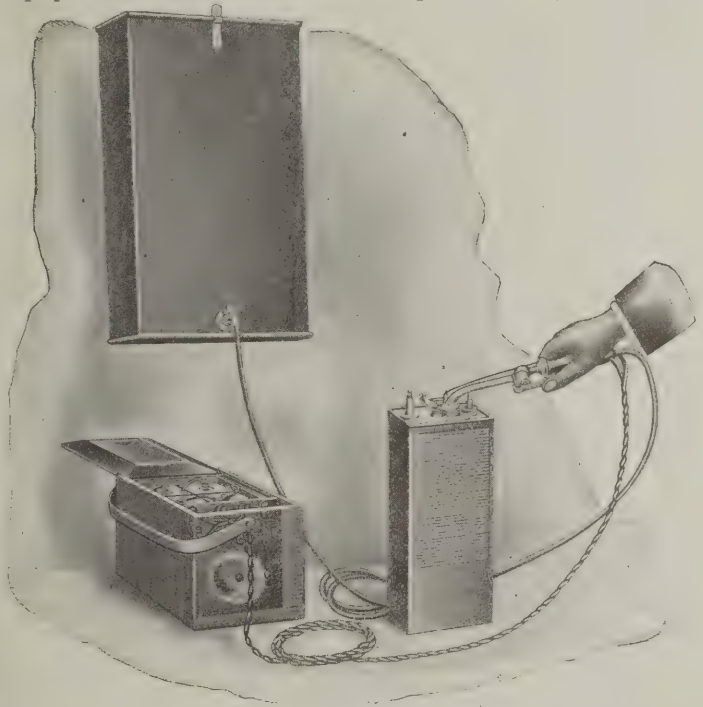


Fig. 11. Automatic Cell Filler.

60 volt equipment, 50. In charging an Edison battery a voltage of at least 1.8 per cell should be provided. This on a 30 volt equipment is equivalent to 45 volts and on 60 volt equipment 90 volts. The manufacturer re-

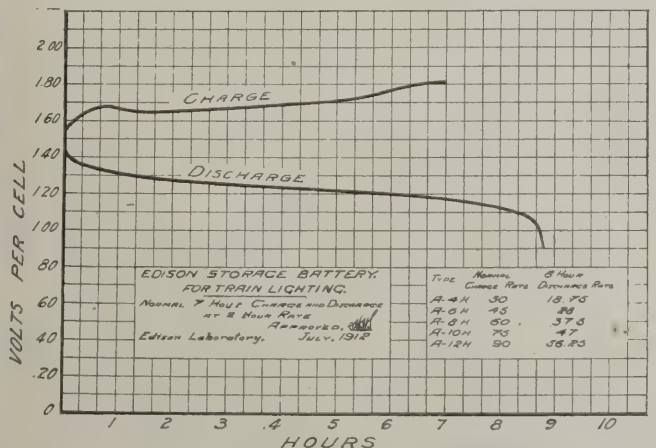


Fig. 12. Curves of Charge and Discharge.

commends that the battery be charged at its normal rate throughout, or if a taper charge be employed, that the rate average normal.

Since the electrolyte does not dissolve or attack the active material or the metal of which the grids are made, it does the battery no harm whatever to stand indefinitely in either a fully charged or discharged condition.

Typical charge and discharge curves are given in Fig. 12.

Instructions for operating this battery center down to the few essentials as follows:

1. Add distilled water to keep plates covered.
2. Replace electrolyte with fresh at infrequent intervals.
3. Keep the outside of the battery reasonably clean and dry.

NEW CARS FOR SANTA FE.

Work has just been begun at the Pullman Shops on fifty new cars for the Sante Fe. These are to be classified as follows: 14-partition coaches, known as "Jim Crow" cars, one smoker and baggage car, 15-smoking cars, 10-combination smoker and mail cars and 10-chair cars. These cars are seventy feet in length, heavy steel underframes and have the wooden superstructure with a heavy steel frame work, making the car stronger than the steel car.

They are to be lighted with second hand axle equipments which have been operating heretofore on sleeping cars. The axle equipments are now being replaced with equipments owned by the Pullman Company. Twenty-one of the second-hand equipments are of the Moskowitz type and the remaining twenty-nine are Bliss type with type "O" generator and "F-7" regulator. Protective resistances are to be used on all of the cars with the exception of the combination smoker and mail cars which have type "C" Bliss lamp regulator. The passenger coaches have center deck lighting with a substantial fixture and a new Iris shade which was exhibited by the Nelite Works of the General Electric Company at Atlantic City. G-30 bulb will be used in these fixtures which are located about 6 ft. apart.

The switchboard and regulators are placed in substantial steel cabinets and the wiring is run in rigid conduit located between the steel carlines and the roof boards. The conduits, therefore, have unusually straight runs, making the conduit and wiring as short as possible.

The batteries are protected with 110 volt enclosed fuses placed in substantial malleable cast iron boxes placed on each end of the battery box in accordance with standard practice.

NEW CAR LIGHTING EQUIPMENT NORFOLK & WESTERN.

The Norfolk and Western Railway have just placed an order with the Edison Storage Battery Co., for 74 sets of 25 cells each for lighting some new passenger cars now under construction.

NEW SMOKE DEPARTMENT ON NORTHWESTERN

The C. & N. W. Ry. announces the appointment of a smoke inspection bureau, the object of which is to eliminate the smoke nuisance in the Chicago district.

This new department will co-operate with the city smoke inspection bureau and will see to it that the smoke from railway locomotives both on the road and in the roundhouses is reduced to a minimum.

Mr. C. W. Corning has been appointed head of the new department.

J. C. CAUSLAND.

June is the month of brides and honeymoons alright, but we didn't really expect that one of our old standbys in the ranks of single blessedness, such as Johnnie Causland, would get tangled up even at such a time as this,—but to make a long story short, J. C. Causland, Chief Electrician of Pennsylvania Lines West, with headquarters at Chicago, was married on Saturday, June 15th, to Miss Anna M. Carlson, at the home of the bride, Evanston, Ill.

This was the day after the Semi-Annual Convention, so Johnnie, as he is known among his friends in the car lighting field, was not with us at Atlantic City, but he

J. C. Causland.

and his bride took their honeymoon trip immediately after the wedding, and, after visiting Atlantic City, made an extended tour through the East.

SIXTH ANNUAL CONVENTION I. E. S.

The sixth annual convention of the Illuminating Engineering Society will be held at the Hotel Clifton, Niagara Falls, Ontario, September 16 to 19. The program of papers that is being arranged includes a number of notable papers which embody the results of some recent photic investigations.

U. S. COMPANY TO DOUBLE THEIR PLANT.

Plans are now made and work just begun on some new buildings which will practically double the size of the manufacturing plant of the U. S. Light & Heating Co., at Niagara Falls.

This new plant will certainly be a testimony to the wonderful advancement in the art of railway car lighting.

P. R. R. MEN VISIT CAR LIGHTING MFGRS.

A party of seventeen men employed in the car lighting department of the Pennsylvania Railroad Company, recently made a visit to the plant of the U. S. Light & Heating Co., of Niagara Falls. It is planned moreover to make a rather extensive tour of inspection of the plants of some of the other more prominent car lighting manufacturers in the near future.

This is the result of a broad minded policy on the part of the Pennsylvania Railroad and is an excellent thing for the car lighting industry. It brings the men in charge of the operation of car lighting equipments personally in touch with the manufacturers of that equipment. Some of the other large roads would do well to emulate the Pennsylvania in this respect.

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Official Journal
of the Association of Railway Electrical Engineers.

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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Fifth Annual Convention.

On October 21-25, the Fifth Annual Convention of the Association of Railway Electrical Engineers will be held in the Auditorium Hotel, Chicago.

Since the organization of the Association in 1908, each year has witnessed marked progress and each convention has surpassed its predecessor both in interest and value of the committee reports and the papers presented and in the size and quality of the exhibits of the manufacturers.

The present prospects are that 1912 will far surpass the 1911 conventon in every respect. Because of the fact that the exhibit space available in the large roof Garden of the La Salle Hotel, was not found adequate to meet last year's needs, it has been decided to hold the convention in the Auditorium Hotel, where more spacious quarters for the various exhibits can be obtained on the ninth floor.

The various committees of the Association have been particularly active during the past year and we may expect some valuable committee reports at this Convention.

Railway Car Ventilation.

August is the time of the year when old Sol is operating at his maximum efficiency, and one of the chief troubles of man is to keep cool. While ventilation may not be entirely a matter of keeping cool, physiologists tell us that this is very largely true. So we believe that it is very timely that we should give this subject some special consideration in this, our mid-summer issue.

The past year has witnessed special activity in the matter of motor driven exhaust ventilation for various types of cars. As described in the issue of the *Railway Electrical Engineer,* an apparently good and efficient system for dining car blower exhaust ventilating was worked out on the Illinois Central Railroad. This consisted of two blowers placed in the kitchen, one exhausting from the ceiling of the kitchen direct, and the other drawing air through a decorative screen over the doorway of the dining room entrance and exhausting upward into the hood over the kitchen stove. Thus a large amount of smoke and steam from the stove would be carried out of the ventilator along with the blower exhaust.

The Santa Fe have made a big step forward in the progress of car ventilation in their air washing equipment installed on the Santa Fe De Luxe Special, as described in the *Railway Electrical Engineer* of January, 1912. This device was intended primarily as an air cooler and purifier for use in crossing the hot desert plains where alkali dust fills the air. This system being the pioneer of its kind, of course, contains many features which can be materially improved upon. That is nothing more than can be expected from every new device which is a radical departure from past practice. There are, however, some things which are fundamentally wrong and should not be repeated in other systems of a similar nature.

In the first place, the air duct for the transmission of either cold or hot air from the washer must be provided with heat insulation so that the cold air will not be heated in the summer time by passing through a tin duct directly under a blazing hot roof, and also that warm air coming from the washer will not be unduly cool in the winter time. Moreover, instead of allowing the cold air to drop down on the passengers heads from the outlet just below the quarter deck as installed in this case, this air duct should exhaust, as in the Pennsylvania system, through frequent openings in a casing enclosing the steam heating coils. With suitable exhaust ventilators in the roof, a current of fresh cool or warm air, as the case may be, would be drawn in at the floor line, pass upward through the breathing zone of the passenger and there being warmed by the body heat of the passenger and car walls, would pass upward and out of the ventilators on the roof. This would then provide pure air to the breathing zone at all times instead of continual dilution of the air by entering at the quarter deck as provided in the present system. Moreover, the drafty effects of currents of cold air coming down on the heads of the passengers will be eliminated. This equipment, however, is a big step toward good ventilation and the Santa Fe is to be complimented upon their originality and their aggressiveness in being the first to make such a radical improvement in car ventilation.

The various types of exhaust ventilators, such as the Garland, Globe and others, are well known. While they provide a good exhaust of foul air when the train is in motion are inoperative when it is at rest.

The problem is to provide clean, fresh air in sufficient quantity and at proper temperature, free from dust, cinders and smoke, at all times, whether the train is in motion or at rest; and one step further, it must be given a certain amount of motion over the passengers in the car. Still air is usually "Bad" air, and a "Stuffy" room

is usually found to be one in which the air is motionless.

Electric fans are the solution of this part of the problem and there should be not merely one or two per car, but six or eight, in order to provide proper air motion.

With a large percentage of passenger cars now electrically lighted there is offered an excellent means of providing motor driven ventilation system, which will operate either alone or as an auxiliary to a purely mechanical system. This then makes the ventilating problem a problem which the electrical engineer must solve, and with the present activity in electric air washers and motor driven blowers designs for railway car ventilation, the coming year will undoubtedly show much progress in this line.

ASSOCIATION NEWS.

Annual Convention.

The Annual Convention this year will be held October 21-25, on the ninth floor of the Auditorium Hotel, and this is going to be the biggest and the best convention we have ever held. But October 21 is not very far off. As a matter of fact, it is a good deal worse than that. All committee reports and papers must be presented to the Executive Committee by not later than September 1, in order that advance copies may be sent the various members before the Convention.

Our Association is each year bigger and stronger than the year before, and each annual convention is a bigger success and a better convention than the one preceding. The Association is now recognized by the Master Car Builders' Association and consulted in all matters pertaining to train lighting.

But it isn't safe to offer too many congratulations to ourselves. It is up to each and every one of us to jump in and make this convention all that it should be.

Remember the date, committee reports due September 1. This means just four weeks left to close up committee reports.

Dues are Due.

Our Secretary, Mr. Andreucetti, tells us that there are a good many of the boys that hav'nt paid their dues. Of course, we know that this is just an oversight, but he says he needs the money and we will have to take his word for it—anyhow we'll all have to be in good standing at the time of the Convention or miss one of the historic times of our lives, so think we had better come across, don't you?

Addresses Wanted.

I am unable to locate the following men and if any of the members can give me definite information as to their present addresses it will be appreciated.

Mr. W. B. Brown, formerly with the I. C. R. R.
Mr. J. Roedel, formerly with the U. S. Light & Ht. Co.
Mr. G. H. Schilling, formerly with the Pullman Co.
Mr. Roy J. O'Leary, formerly with the Pullman Co.
Mr. Harry S. Johnston, formerly with the A. T. & S. F.

Yours very truly,
JOS. ANDREUCETTI,
Secretary and Treasurer.
Rm. 411 C. & N. W. Terminal, Chicago, Ill.

TRAIN LIGHTING IN ENGLAND.

It will be remembered that in the February and March issues of the *Railway Electrical Engineer* there was published an excellent article by Mr. Roger T. Smith, Elec. Engr., of the Great Western Ry. of England, describing the various car lighting systems in use and giving some costs of operation. This paper was discussed at the March meeting of the Car Lighting Club, a report of which is published in the April issue of the *Railway Electrical Engineer.*

The costs given by Mr. Smith, however, were so much lower than anything obtained in this country ($3.10 per car month by the brake vehicle method) that the Secretary of the Car Lighting Club was instructed to request more detailed information as to the items which went to make up these costs.

The following letter has just been received from Mr. Smith in reply to this request.

"Gentlemen of the Car Lighting Club:—

"I am very sorry not to have sent you the information you asked for as to the cost of maintenance of our coaches at an earlier date, but there has been considerable discussion with my General Manager and doubt in my own mind as to the proper way of reckoning the maintenance per coach when the number of equipped

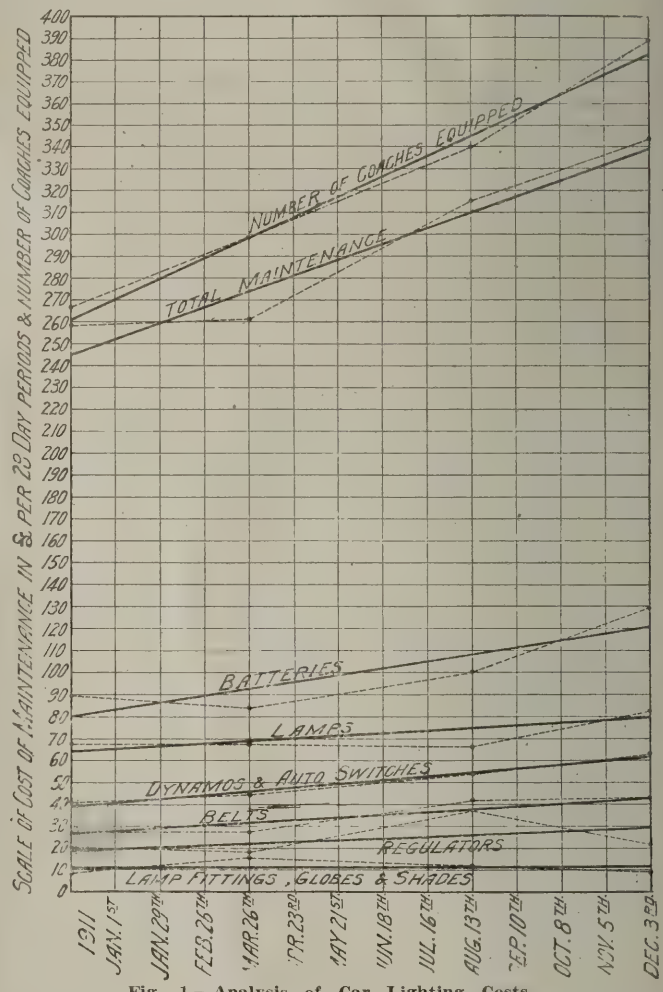


Fig. 1.—Analysis of Car Lighting Costs.

coaches is rapidly increasing, and I did not want to give you any figures which could not be substantiated officially by our General Manager's Department if need be. There is no doubt that the proper unit for comparison is the car-mile, but we cannot obtain the car miles of electrically lit coaches as distinct from others not so lit, and the cost per coach is the only unit at present available.

"The number of coaches equipped during 1911 has increased 47 per cent, but it has been necessary to provide a train staff for meeting not only the requirements for maintenance during that year but also for an additional number of coaches this year. It is not possible to have less than one man at a depot, and we are in the condition in which a number of depots throughout our 3,000 miles of line have had to be established and a staff provided which will be capable of looking after more than double the number of coaches actually equipped. Under these circumstances the average number of coaches

equipped during 1911 does not really give a correct divisor for the cost of maintenance.

"Fig. 1 shows the costs during each 28 day period of the various items, the costs for each period, and for four similar periods at the end of 1910 and the beginning of 1912, being averaged to get the curves shown dotted on the diagram. These again are averaged to get the full line slopes shown. I believe that these diagrams are as nearly correct as they can be got. The costs include all departmental maintenance charges, including management, but nothing else.

"At the end of the year the cost per coach per annum was £11:10:0 for Leitner equipments only, and £12:8:0 for all equipments. This gives a sum in excess of the £9:10:0 per coach per annum stated in my paper, which was for Leitner equipments. The slope of the curve if continued at the same rate as for 1911 would bring the cost per coach down to £9:10:0 some time in 1913, but our maintenance per coach this year is decreasing at a greater rate than in 1911 and when the number of coaches equipped is about doubled, the cost per coach per annum will be approximately £9, and should the brake vehicle method be considerably extended it will be very much lower.

Group Attending Conference of Harriman Lines Electricians.

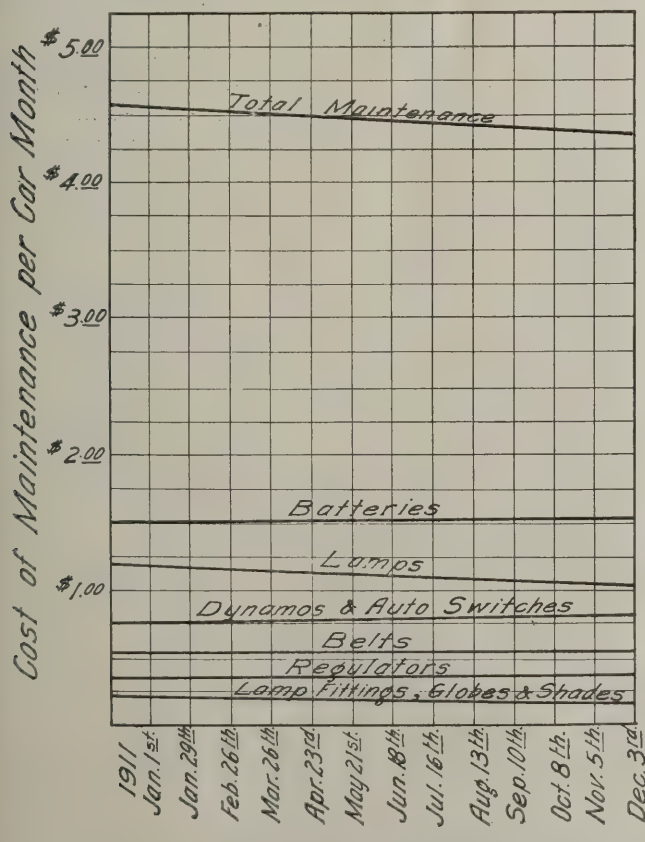


Fig. 2. Itiimized Costs Per Car, Month Basis.

"I should expect that the great difference between the cost of maintenance with you and in this country is partly accounted for by the fact that you have more light and larger equipments, so that the comparison per coach is fallacious, and partly that your wages must be very much higher than ours. In the memorandum attached I give the wages we pay to the different grades and it would be interesting to know how these compare with your wages.

GREAT WESTERN RAILWAY (England.)
Wages of Electric Train Lighting Staff.

Grade	Minimum pence per hour		Maximum pence per hour	
Battery Attendant	6	($0.12)	10	($0.20)
Fitter	8	($0.16)	10	($0.20)
Laborer	3.5	($0.07)	6	($0.12)
Electrical Examiners	8	($0.16)	9	($0.18)
Assistant Examiners	6	($0.12)	8	($0.16)

"I am very interested in the abstract of the discussion at the Car Lighting Club, which appeared in the April number of the *Railway Electrical Engineer*, and am very glad if my paper has given my Electric Train Lighting brethren on the other side of the Atlantic any excuse for looking at their problems from a slightly different point of view. I can assure you that your paper and more especially the work of the Committees of the Association of Railway Electrical Engineers is a very great help to us in England, who in general work on much more conventional lines.

Yours very truly,
ROGER T. SMITH."

Ventilation of Railway Cars

Although this subject is an old and a very much discussed one, when it is considered in the light of recent development and improvements in ventilating apparatus we have a better understanding of its laws and requirements. The Master Car Builders' Association has appointed various committees to investigate this subject whose reports have been of considerable value although they have not contained much experimental or research work. The informal discussion on this subject at the annual meetings of the Railway Electrical Engineers has also brought out many points of interest and value. The report of a committee of the American Medical Association on the "Ventilation of Cars" (1911) of which Thomas R. Crowder, M. D., of the Pullman Co., was Chairman, presents some excellent information on the subject as well as a complete resume of developments up to date.

The above committee report and a paper entitled, "A Study of Ventilating Sleeping Cars," by Dr. Crowder, have been of considerable assistance to the writer in arranging this article.

There have been, during the past few years a great many different devices and systems of car ventilation employed and a great many more designed on paper. In this article, however, we must confine ourselves to the consideration of the types more generally used.

Deck Sash Method.

This is probably the oldest and at the present time the most generally used system of all, although its one salvation may have been, as Dr. Evans said in his discussion at our annual convention last fall, that, "It isn't worth a —— If it worked as it is designed to it would let cold air directly down on the heads of the passengers and would never be tolerated by the traveling public."

The Deck Sash ventilator is a well-known one and requires no description. The actual results obtained from this type of ventilation are extremely variable and uncertain. The openings may act either as inlets or outlets and are subject to any change in the wind. They accordingly demand constant supervision of the train crew.

The Exhaust Method.

The most extensively used type of exhaust ventilator is that known as the Garland. This was developed about 7 years ago and is now in use on over 8,000 Pullmans and coaches. The ventilator operates on the injector principle and removes the air from the upper portion of the car by exhausting it through the deck sash windows. A modification of this type providing a blower for ventilating the car while it is at rest, is described on page 73 of this issue.

The operation of the simple exhaust type is dependent upon train motion and of course is inoperative when the train is at rest. It has been shown by repeated experiments that each ventilator of this type will remove about 370 cubic feet of air per hour for each mile of train speed, or approximately 15,000 cubic feet per hour at the ordinary speed of passenger trains.

At high speed the operation of this ventilator is almost entirely independent of the direction of the wind but at the lower speeds the strong side winds may effect its operation somewhat, causing a decreasing exhaust on the windward side and increase on the lee side.

Another well-known type of exhaust ventilator is the Globe ventilator which utilizes the train motion for creating an exhaust of air through the roof. This, however, is not so positive in its action as the Garland type.

Another type of exhaust ventilator recently developed is the Utility ventilator which is described on another page of this issue.

Automatic Ventilator.

In this system of ventilation the deck sash is used both as an inlet and an outlet for the air and each window is separated into two portions, a forward and a rear, with a 12-inch space between. A 6-inch vane is mounted on the outside of this space and when the car is in motion this creates a pressure in front and forces the air in through the forward opening while at the same time it acts as a deflector for the rear opening and draws the air out at that place. The rate of entrance of air will always depend upon train speed, but becomes effective at very low speeds, hence is used for street car work as well as on railroad cars. This type is now in use on over 5,000 cars on both classes.

It should be noted, however, that because of the fact that the outlet and inlet are very close together a large part of the air admitted into the car will be drawn directly out again without passing through the breathing zone of the passengers. So anemometer readings giving the number of cu. ft. of air admitted and exhausted cannot be taken as a real measure of the efficiency of the system.

Pennsylvania Method.

The Pennsylvania Railroad Company, under the direction of Dr. Dudley, developed a system of ventilating which is entirely different from any of the types described so far. The air is brought in through hoods located at diagonally opposite corners of the car, conducted downward through vertical drums from which it enters conduits located under the floor and extending the whole length of the car along each side. From the upper side of these two conduits, openings are made into the casing which contains the train heating pipes and ducts lead off laterally through this casing and extend below each seat. The intake of air depends upon the scooping effects of the hoods when the train is in motion, while Globe ventilators are placed on the roof for removing the air from the upper zone of the car. In this way a constant movement of air from the floor to the roof is maintained.

An arrangement is provided whereby the train men can adjust the flow of air so that the car will not be unduly cooled off when going at high speed in cold weather. This system is designed to supply about 60,000 cubic feet of air per hour and experience has shown that it is easily capable of doing this.

The above four methods represent pretty well the types of ventilating apparatus which have been extensively used on cars up to the present time. A great many modifications of each type have been designed and some have given fairly good results. All of the above types, however, depend almost entirely on the motion of the train for proper ventilation.

While a great many agitating fans have been installed with excellent results in a majority of the electrical lighted cars, fans and blowers as a means of forcing fresh air into the car and exhausting foul air, have found but limited application. The blower ventilator described on page 73 of this issue, however, is a step in the right direction. Without doubt the next few years will witness a marked development in the ventilating of cars by the motor-driven blower exhaust method.

Methods of Computing Air Supply.

The usual way of determining the supply of air, which any car is receiving, is to place an anemometer either at the inlet or outlet, whichever is the most convenient for purposes of measurement. The number of cubic feet of air passing through that opening is then readily measured. This, however, may or may not be a true indication of the real ventilation of the car, for as in the case of the Automatic type ventilator, where the inlet and the outlet are in close approximity of each other,

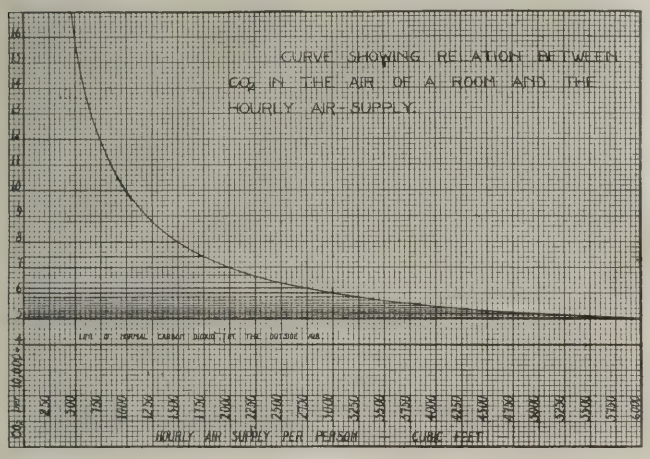


Chart 1.

only a small portion of the air admitted to the car may actually pass through the breathing zone of the passengers. In this case and in some others of the deck sash type, the anemometer readings would give an entirely false idea as to the true ventilation of the car.

The amount of fresh air that actually enters the breathing zone is the only true criterion in considering the efficiency of any ventilation system. This may be measured fairly accurately by determining the amount of carbon dioxide which the air of this zone contains.

The problem is simple. The average person produces approximately 0.6 cu. ft. of carbon dioxide (CO_2) per hour and the air surrounding a car has been found to contain very close to 4 parts in 10,000. The amount of air supplied by the ventilating system of the breathing zone is then expressed by the following equation,

$$A = \frac{0.6p}{x\text{-}0.0004}$$

in which A is the air supply in cu. ft. per hour, p is the number of people in the car and x is the per cent. of CO_2 found in the car air. The accompanying curve illustrates pretty well the manner in which this rule may be applied. If, for example, it is found in a car that there are 8 parts of CO_2 in 10,000, upon referring to the curve, Fig. 1, it is seen that this indicates a ventilation of 1500 cubic feet of air per person per hour. A great many tests of various types of ventilating systems have been made and presented in the Committee report above referred to. This might be summarized as follows:—

1. Natural Ventilation (Deck Sash Method).

Parts CO_2 in 10,000	Cu. Ft. Per Hour.
a. Fully closed car 8.33	18,500
b. With open deck sash 7.19	28,300
c. With open-end door (decks closed) 5.75	32,500
c. With open-end door (decks open) 5.40	40,700
d. With open windows, more than	100,000

2. Exhaust Ventilation (the Exhaust Method).

Parts CO_2 in 10,000	Cu. Ft. Per Hour.
a. Fully closed car 6.20	40,600
b. With open-end door 5.50	57,900
c. With open windows, more than	100,000

Pullman sleepers, however, present a somewhat different problem as the car is divided into a number of small compartments at night. Over 1200 separate tests were made and were taken under various conditions of a car in motion and at rest with the type natural and exhaust type of ventilation. These are summarized as follows:—

1. Natural Ventilation (Deck Sash Method).

Parts CO_2 in 10,000	Cu. Ft. Per Hour.
Body of car 7.32	29,700
Lower berth 8.32	1,389
Upper berth 7.73	1,268

2. Exhaust Ventilation (the Exhaust Method).

Parts CO_2 in 10,000	Cu. Ft. Per Hour.
Body of car 6.33	40,500
Lower berth 6.96	2,027
Upper berth 7.19	1,883

The Hygiene of Ventilation.

The number of cubic feet of fresh air supplied to a car is usually considered the proper criterion by which to judge the ventilation of a car. As a matter of fact medical authorities tells us that the mere deficiency of oxygen or excess of carbon dioxide is not responsible for the discomfort experienced in a crowded car. The comfort of the passengers depends more directly upon whether or not the body is given an opportunity to rid itself of its excess animal heat. The human body is constantly generating heat, in fact, if a person were incased in a heat proof jacket which retained all of the heat generated in the body, inside of 36 hours he would be up to the boiling point.

This constant cooling off process, which is so essential to human life and comfort is effected by both the convection currents of air immediately adjacent to the body and by evaporation of moisture through the pores of the skin. The amount of direct radiation to the surrounding air is dependent upon the temperature of that air. The colder the temperature the more heat radiated from the body and vice versa. The amount of heat carried off by the evaporation of moisture depends upon the humidity of the air in the car, but both of these cooling effects are greatly increased by motion of the air in the car caused by electric fans or open windows.

It is seen that the air within a car has two principal functions, a chemical and a physical. For the performance of its chemical functions it must contain a sufficient amount of oxygen and be free from poisonous gases: for the performance of its physical functions it must have the proper temperature, humidity and motion to enable it to carry away the surplus body heat. While every one will agree that outdoor air is far more preferable to air contaminated even to the slightest degree, air may contain a comparatively large per cent. of CO_2, provided the air temperature, humidity and air motion are properly taken care of. Normally the point at which the passengers begin to feel the ill effects of "stuffy" air may vary from 6 to 20 parts of CO_2 in 10,000, but as above stated the consideration of temperature, humidity and air motion are of such great importance that the chemical effect of the CO_2 present in the air is greatly lessened.

In a talk before our Annual Convention last fall, Dr. Evans said that the agitating fan was of greater importance in car ventilation than seems to have been considered. These fans should be run not only in the summer time but all the year around. He said, "It is all right to kill hogs when the frost comes, but that isn't the time to kill people," presumably by failing to provide sufficient air motion. He also maintained that two agitating fans per car was far from a sufficient number; there should be enough to maintain a constant air motion in all parts of the car.

In the winter time it will probably be rather difficult to operate fans to the satisfaction of the traveling public, for at that time of the year the humidity is low, hence, the cooling effect of evaporation high. Cars often become too cold, so that the added cooling effect of the fan might become objectionable. With a proper balance of temperature, humidity and fan breezes, however, winter travel may be made even more pleasant from a ventilation stand point than summer travel.

Of these three factors, temperature is the most important. A "stuffy" car generally means a car that is too hot and "bad air" is usually air that will not consume the body heat rapidly enough. When the car temperature does not rise above 70° F. there will be little complaint from passengers, although, the greatest comfort for the average person ordinarily dressed seems to be between 64-68. In Pullmans at night when the passengers are sleeping under heavy blankets a temperature of 50° F. is more healthful.

Where electric fans are operated in the winter time as recommended above, it will be found that a somewhat higher temperature in the car will be required, but the added comfort of the passengers will undoubtedly more than warrant the additional expense. It may be maintained by some that the natural leakage of cold air through the window crevices in the winter time will be sufficient to maintain proper motion of the air where sufficient fan motion is provided, however, this is an uncertain quantity and unhealthful, but by the use of electric fans, the drafty effect from cold windows will be largely eliminated and proper air motion maintained at all times.

Summary.

In the above discussion, we have endeavored to lay before our readers the following fundamental principles in car ventilation.

1. It is the amount of fresh air actually forced into the breathing zone that is the real measure of efficiency of any ventilation system. This is determined by means of measuring the amount of CO_2 present in the breathing zone. Anemometer readings of exhaust or entrance of air into the car may be seriously misleading.

2. The experiments made by Dr. Thomas Crowder and others have shown that respiratory contamination of air in a car is seldom serious.

3. The air performs two principle functions for the body, one chemically and the other physically. The chemical supplies the oxygen to the blood while its physical property is to carry away excess heat which the body generates. The object of any ventilating system is to supply reasonably pure air in sufficient quantity to perform both of these functions properly. Much experimentation has shown that usually poor ventilation is due to high temperature, high humidity and poor air motion, rather than the lack of oxygen or the presence of CO_2.

4. It is immaterial whether ventilation and heating are partly combined or wholly separated so long as the requirements of temperature, quantity of air, humidity and air motion are taken care of. When railroad men more thoroughly understand the real causes of discomfort due to poor ventilation much more effective work can be done toward remedying those causes and making railway travel even more enjoyable than at present.

New Electric Locomotives for N.Y.N.H. & H.R.R.

Work is now well under way on a consignment of 39 heavy service, electric locomotives (Figs. 1 and 8) that are being built by the Baldwin-Westinghouse combination for the New York, New Haven & Hartford Railroad Co., for use on its lines between New York and New Haven. This is one of the largest consignments of electric locomotives that has ever been under construction and is of further interest in that the design adopted is considerably different from any heretofore used for electric engines and in that 36 of the engines are arranged for single-phase service only. There are no decidedly new features involved, as all of the methods used have been heretofore employed. But never before have they been utilized in the combination devised for these 39 engines.

In their construction have been combined what have been shown in everyday road service to be the best features of the heavy locomotives that have been built in the past. An 8-motor driving arrangement similar to that first used in the 069 New Haven Locomotive and an articulated running gear similar to that used for the 072 class locomotives has been adopted.

Each engine is driven by four twin-motor (Fig. 7) units, 8 motors in all—with one twin-motor unit mounted over each driving axle. This arrangement has shown itself to be a very desirable one for the following reasons:

1. Peripheral speed is a limiting feature in railway motor design. With two small motors it is possible to use a rotative speed approximately twice that possible with one large motor. Each motor has therefore one-half the number of poles of practically the same size as would be required by one equivalent large motor. Therefore two of the small motors have practically the same number of parts, such as field coils, armature coils, and brush holders as would be required by one large motor.

2. Each of the small motors has a diameter practically half of that of one equivalent large motor, hence a saving in weight and space results.

3. A further saving in weight results because each small motor exerts but one-half the torque that must be exerted by one equivalent large motor; therefore a single gear meshing with the pinion of each motor can be used in place of two gears necessary with a small motor of the same total capacity.

4. The use of a single gear being possible because of the reason of item 3, the motor can be longer, which permits of a more economical design.

5. The motor armatures are interchangeable with those used on the New York, New Haven & Hartford and the New York, Westchester and Boston motor cars.

6. Finally, eight motors actually cost less than do four having the same aggregate output.

As to the articulated running gear, (Fig. 2) adopted for these thirty-six engines, it is very similar to that used for the 072 type New Haven locomotives (the 072 engines were driven by four motors). A running gear of this type has shown itself to be very "easy running" as far as shock to the equipment in the locomotive cab is concerned, which is one of the reasons why it has been used.

The cab rides on top of semi-eliptic and helical springs in series. This spring arrangement resembles, in general

principle at least, that which is employed for, and makes riding easy in passenger cars. In general design and arrangement all of the locomotives are the same, but the three bearing the road numbers 073 to 075 are for

Fig. 1. Showing Pantagraph Trolley.

both alternating and direct-current operation in fast freight and heavy passenger service. These latter are designed to handle a trailing load of 800 tons at a maximum speed of 45 miles per hour. When operating on single-phase alternating current they take energy at 11,000 volts and 25 cycles, and on direct current at 650 volts.

Thirty-six of the locomotives which bear the road numbers 076 to 0111 are equipped for 11,000 volt, 25 cycle, alternating-current operation only. They are primarily for fast freight service but will also sometimes haul passenger trains. They are designed to handle a trailing load of 1500 tons at a maximum speed of 35 miles per hour. All 36 of the locomotives are designed to exert a maximum tractive force of 40,000 pounds.

The four pairs of driving wheels and two pairs of small leading wheels are in two groups, each group having outside frames of the bar type. These cast steel frames are four inches wide and are similar to those used in steam locomotive practice. The pulling and buffing strains are transmitted entirely through the truck frames which are braced transversely at the end of the trucks and between the driving axles. The inside faces of the driving pedestals are finished to a taper and are fitted with adjustable wedges. The pedestal binders are cast steel.

The drawbar pull is transmitted from truck to truck by means of a draw bar adjusted to leave a ½ inch maximum clearance between the end ties or bumper guides of the trucks when all the slack is pulled out. The truck cross ties or bumper guides (Fig. 4) which are located on trucks at the mid-length of the locomotive, are equipped with spring buffers which assist in transmitting the buffing shocks from truck to truck. The drawbar has a slotted hole in one end. With this arrangement all pulling strains are transmitted through the drawbar and pushing and buffing shocks through the spring buffers, and bumper girders.

The principal dimensions of all 36 of the locomotives are as follows:

Length between coupler faces, 50'-0".
Width over all, 10'-3".
Height to top of cab, 12'-6".
Height to top of clearstory, 13'-10".
Wheel-base, rigid, 8'-0".
Wheel-base, total, 40'-6".
Driving wheels, diameter, outside, 63".
Driving wheels, diameter, centers, 56".
Driving journals, 7"x13".
Truck wheels, diameter, 36".
Truck journals, 6"x12".

Weight on driving wheels, for A. C.—D. C. engines 182,000 pounds.

Weight, total locomotive, for A. C.—D. C. engines (073 to 075), 240,000 pounds.

Eight, No. 409C, single phase, commutator type, series motors (Fig. 7), having a capacity of 170 h.p. on a one hour rating drive each locomotive. The motors are grouped together in pairs. The two motors of each pair —a right hand and a left hand motor—are bolted together so as to form a unit. One pair of motors is mounted rigidly on the truck frame over each of the four driving axles. Each pair of motors is provided

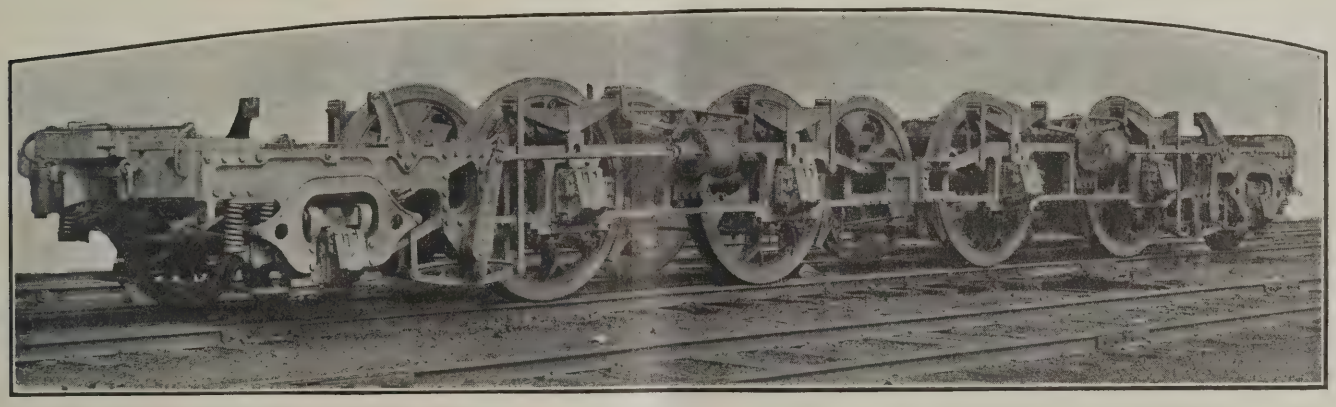


Fig. 2. The Articulated Truck Showing Running Gear.

with two axle bearings which carry a quill concentric with and surrounding the axle. A single gear is mounted on one end of the quill and into this gear mesh the two pinions keyed on the motor armature shafts.

Mechanical connection between the quills and the driving wheels is effected through helical springs which are mounted between the driver spokes and the projecting arms on each end of the quill. A radial clearance of 1½ inch is provided between the inside of the quill and drive wheel axle, so that the drivers are free to follow irregularities in tracks.

This method of mounting relieves the axles of the dead weight of the motors and insures that the opera-

tion of the locomotive will be easier on the tracks. The tops of the motors extend into the cab about six inches above the floor line. A low deck is built over each pair of motors and doors are provided in the decks in such positions that free access to the commutators and armature bearings is afforded.

Flexible leads of ample length to accomodate all movement of the motors relative to the cab extend through insulating bushings in the floor and electrically connect the motors with the control apparatus.

Of the 39 locomotives, three are arranged for operation on either alternating or direct current and these are provided with control equipment that can be used in either service. Therefore the pneumatically-operated

Fig. 3. Engineer's Operating Equipment in Cab.

control switches work in combination with a transformer and preventive coils when the locomotive is receiving alternating current energy and in combination with grid resistors when it is receiving direct current.

Each pair of motors is connected permanently in series. In alternating-current operation the four pairs are connected in multiple and on direct current they may be connected two pairs in series or all four pairs in parallel.

When operating on alternating current from the line at 11,000 volts the energy passes through an oil circuit breaker to the primary of a main transformer and thence to ground. A number of taps are provided on the secondary winding of this main transformer and are connected, through preventive coils, by means of the pneumatically-operated switches to the motor circuits. There are twelve voltage steps on the transformer winding, nine of which are for running points.

The pneumatic switches, used for operation on alternating current are assembled in one group. This group is located close to the transformer. Reversal of the direction of rotation of the motors is effected with two pneumatically-operated drum type reversers. Each reverser is so connected as to handle two pairs of motors. When the locomotives are on direct current the control of the motors is accomplished with two other groups of pneumatically operated switches which connect the pairs of motors in series and in parallel, in combination with the resistors. The switches and resistors used for operation on direct current are supported at the center of one end of the locomotive. The switches are arranged in one straight line with the resistors directly above them,

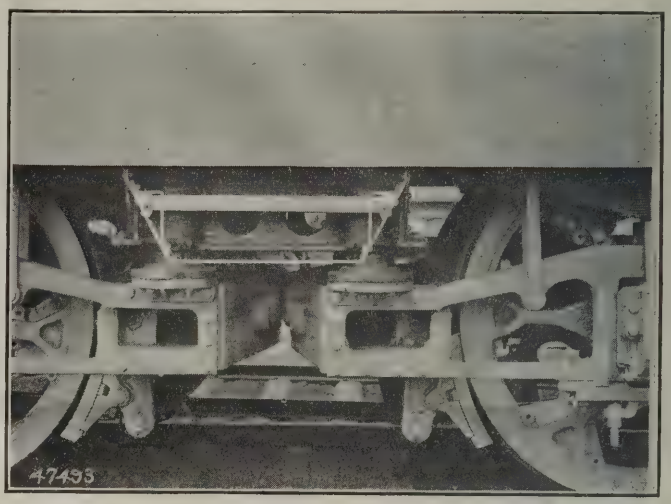


Fig 4. Spring Buffers and Bumper Girders.

so that the connecting leads between switches and resistors are of minimum length. Fig. 9 shows interior of locomotive for single phase operation.

Two master controllers, one located in each end of the cab, are provided. See Fig. 3, showing operating equipment. With these the operation of the pneumatically-operated switches and reverser, hence the motors, can be regulated when a locomotive is running either on alternating current or direct current.

The Sirocco type blowers, for handling cooling air,

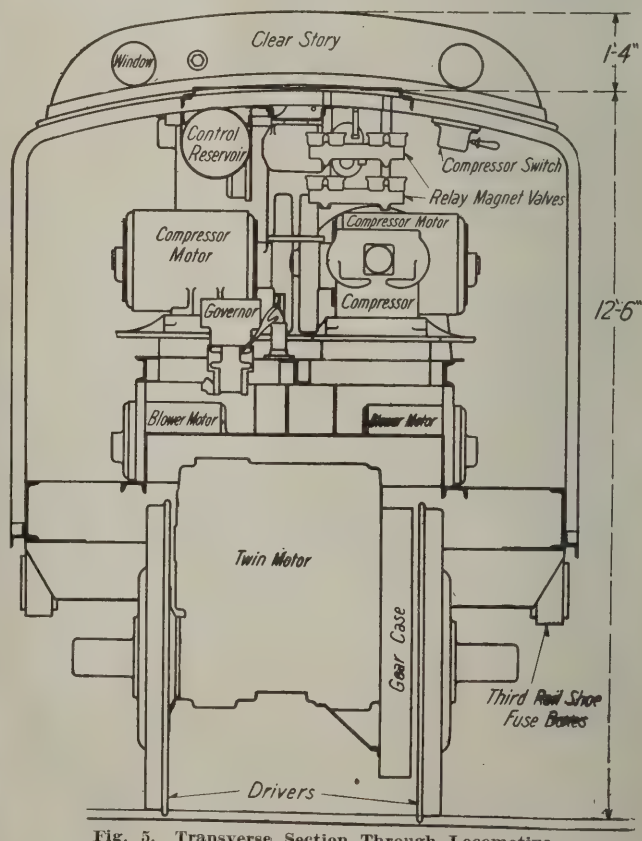


Fig. 5. Transverse Section Through Locomotive.

each driven by a small alternating current direct current motor, are located in the center of the cab directly under the main transformer. These blowers draw their air from outside of the locomotive and discharge it through

the main transformer, motors and resistors. The equipment is thereby maintained at a moderate temperature even when operating under severe overloads.

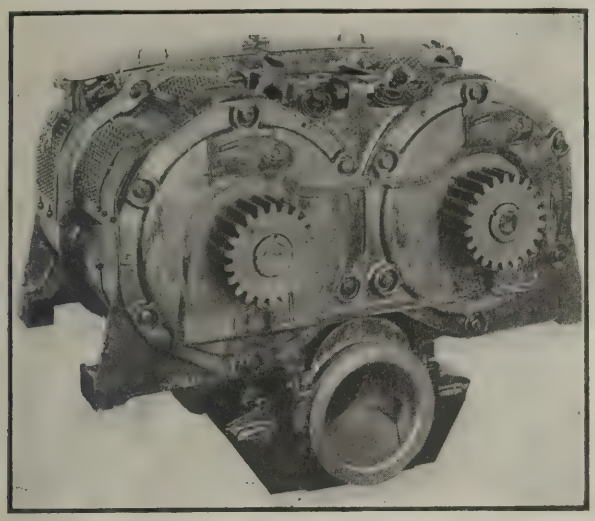


Fig. 6. Twin Motors Assembled, Pionion End.

A double E. L. air brake equipment is provided on each locomotive. Two compressors each having a capacity of 50 cubic feet of free air per minute, are mounted within the cab to supply air for the brake and control apparatus.

Brake shoes are applied to all of the driving wheels and separate pairs of cylinders are provided for each group of wheels. The brakes can be applied to one group with a hand wheel located in a cab so that a locomotive can be held while standing in the yards.

An oil burning steam heater plant, capable of supplying 800 pounds of steam per hour, is installed in the three alternating-direct current locomotives for the heating of passenger trains.

For collecting the current there are two pneumatically-operated pantagraph trolleys for use with an overhead wire, and four pneumatically-operated third rail shoes are provided for use in the direct-current zone. There is also a small overhead direct-current shoe-type collector for use at cross-overs. All of the collector devices are arranged so that they are under the control of the engineer at all times from either of the control positions in the locomotive cab.

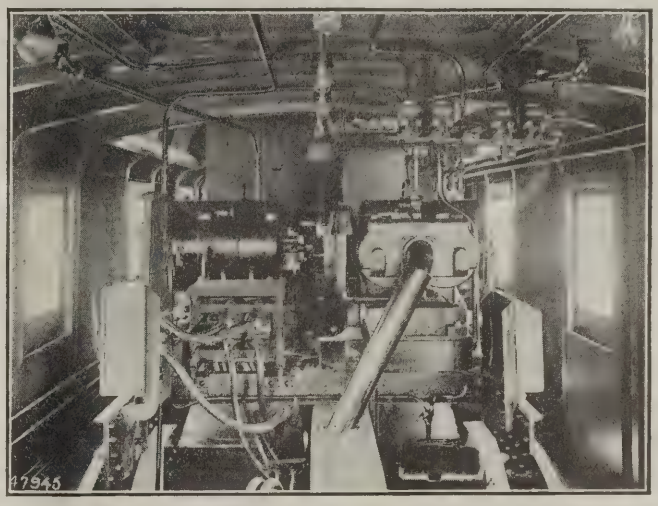


Fig. 9. Interior of Cab Showing Reverser, Air Ducts, Motor Generator for Charging Storage Batteries, Air Compressor and Transformer in the Back Ground.

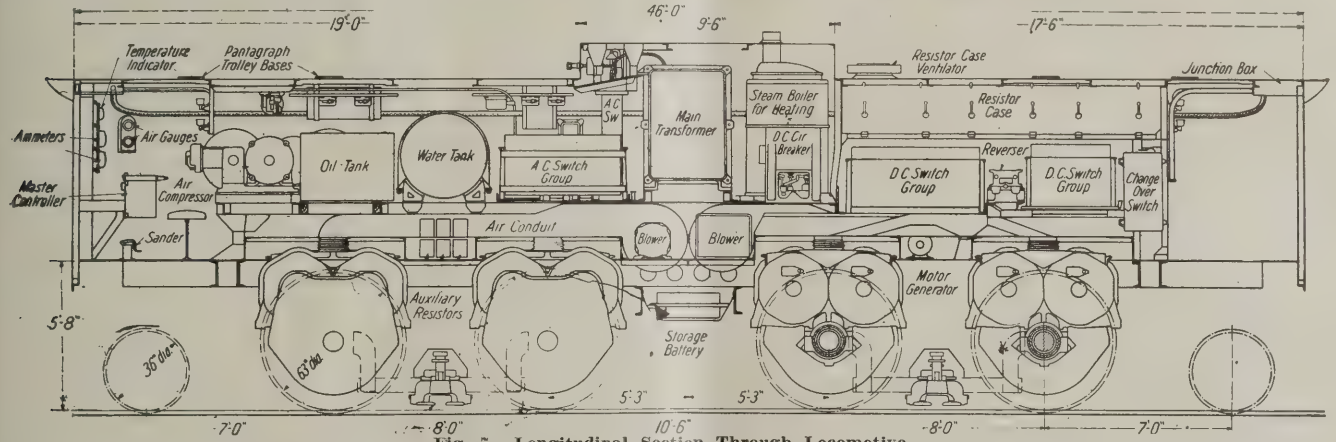


Fig. 7. Longitudinal Section Through Locomotive.

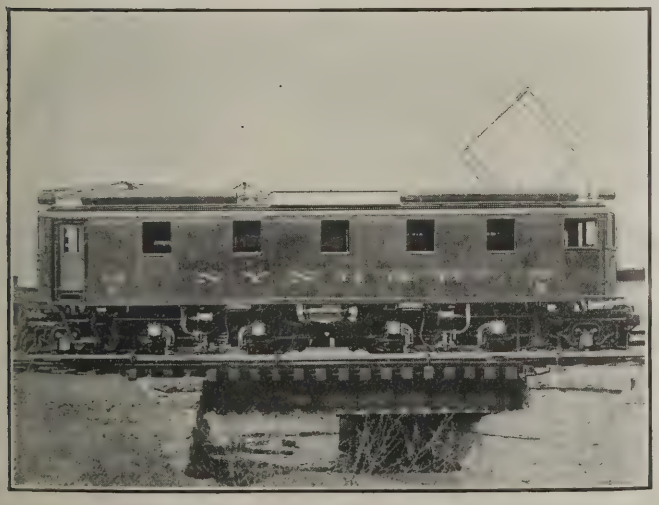


Fig. 8. Side View of 8-Motor Electric Locomotive.

NEW COPPER CLAD CATALOG.

The Duplex Metals Co., of Chester, Pa., have just issued a well illustrated little booklet, which is a complete treatise on the subject of copper clad steel wire. It is artistically gotten up and well worth the time of any one interested in this subject, as it contains much information of scientific as well as practical value. A copy will be furnished upon request.

Editor's Note.

The article published in our June issue describing a new type of round-house lighting, which employed special reflectors mounted on the wall about 8 feet from the ground, was misleading in regard to the matter of giving proper credit for the design of this system. This type of round-house lighting was originally designed by Mr. W. J. Bohan, Mechanical Engineer of the Northern Pacific Railway Company and there are at the present time over 1,000 in use on the Northern Pacific and Great Northern Railroads.

Relation of Central Station Generation to Railway Electrification

Mr. Samuel Insull, President of the Chicago Commonwealth Edison Company delivered a paper on the above subject before the 29th Annual Convention of the American Institute of Electrical Engineers. This, coming from one of the best known authorities in the central station field, has much authentic information, and should received the careful consideration of all railroad officials

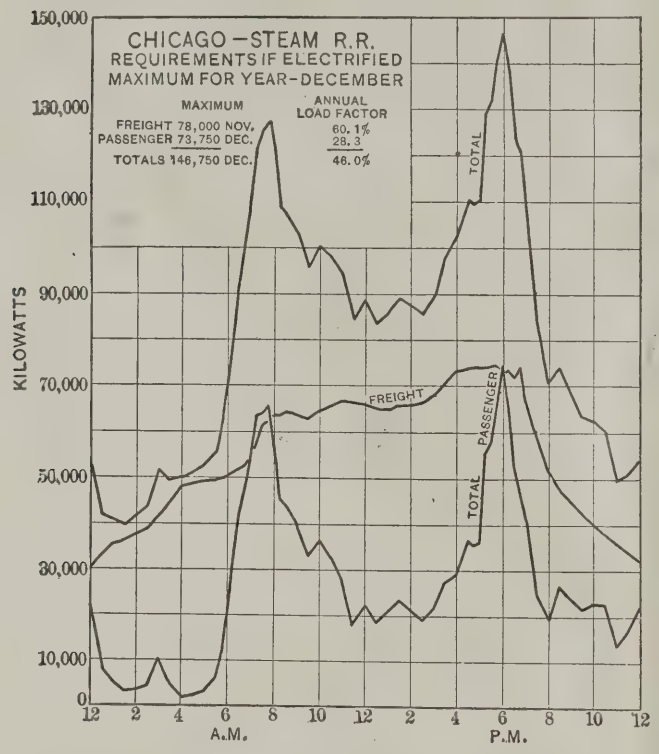


Fig. 1. Power Required for Electrification of all Chicago Terminals.

whether immediate electrification is contemplated or not.

Mr. Insull opens his paper by saying that he is not in sympathy with any agitation to force steam railroads of this country to electrify, nor does he propose to discuss in this paper what might be termed "technique" of electrification, that is, the special system that should be used.

He said that the large amount of energy which the railroads required for electrification is really the one thing that should turn them to central station men for assistance. As this power, however, is only about 15% to 20% of the total demand for energy in any community, the problem is not a very serious one for the central stations to handle.

Mr. Insull presented table of dimensions showing the amount of power consumed by the various industries in New York, Boston and Chicago, and that out of a total of 650,000 k.w. consumed in New York, but 55,000 was required to operate the electrified service of the Pennsylvania, New York Central and the N. Y., N. H. & H. R. R.

As to the requirements of Chicago if all railroads were electrified, Mr. Insull presents the accompanying chart, more detailed information, however, is given as an appendix to his paper.

Mr. Insull advocates very strongly the centralization of power in large generating stations, and presents data upon which he bases the claim that a saving of $3,000,000 per year in operating expenses could be made in New York alone at the present time, if the system of centralization of production and the centralization of primary distribution, such as he recommends, were adopted. At the present rate of growth business is bound to double in 10 years so that the saving which would be effected 10 years hence when capitalized at 5% would represent a money value of $140,000,000 to $175,000,000.

The amount of property which would be realized and made available for other purposes by this centralized power generation system would be worth approximate $18,000,000. Surely this is a matter worthy of the most careful consideration of the greatest engineers and worthy of the attention of the greatest financiers in the country. It is conservation of the truest order.

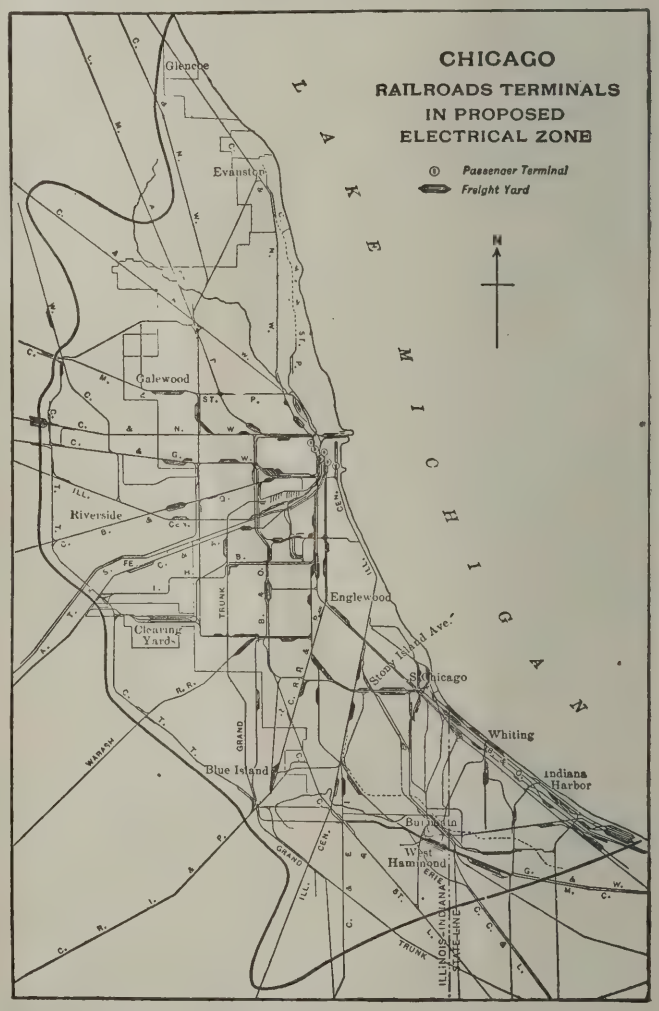


Fig. 2. Plan of Chicago Terminals in Proposed Electrical Zone.

As an appendix to Mr. Insull's paper, some computations made by Mr. Paul Bird, Mr. H. P. Gear and Mr. E. J. Fowler were presented. These give us an idea of the electrical power requirements of various railroads entering Chicago if a general electrifications of these roads were adopted and traffic conditions were continued on essentially the same basis as at present.

With the railroads actually electrified however, there is no question but that great changes in freight terminals will be made, and that a large number of the freight cars that now come through the heart of the city will pass around and outside the city limits, and possibly even outside the electrified zone.

It was found that during the month of November and December freight traffic in Chicago was at its maximum. Based on the traffic of December 1911, the maximum demand and current consumption of the various railroads are as follows:

Railroads	Kilowatts			Capacity in kilowatts				
	Freight load	Pass. load	Total load	Generating stations	Substations	No. of substations	No. of lines	Length of lines
1. Ill. Cent. M. C. Pass.	4,600	20,400	25,000	37,500	37,000	7	19	329,000 ft.
2. L. S. & M. S. M. C. R. R. Freight. C. R. I. & P. Pass.	8,750	7,750	16,500	24,000	28,000	7	14	255,000 ft.
3. C. & N. W.	8,000	25,000	33,000	50,000	51,000	8	19	479,000 ft.
4. C. M. & St. P.	4,350	3,050	7,400	14,000	14,000	4	8	121,000 ft.
5. C. & Gt. W. Grand Trunk. B. & O. C. T. I. H. Belt	10,500	2,000	12,500	22,500	26,500	15	21	1,224,000 ft.
6. P. F. & W. & C. P. C. C. & St. L.	5,700	2,000	7,700	14,000	20,000	10	12	637,000 ft.
7. Erie. C. I. & L. C. & W. I. Wabash. Belt	16,300	3,200	19,500	30,000	32,000	10	18	290,000 ft.
8. Santa Fe. Alton	2,600	2,000	4,600	9,000	6,000	2	4	29,000 ft.
9. C. B. & Q.	5,400	5,400	10,800	16,500	14,000	3	8	47,000 ft.
10. C. R. I. & P.	2,400	3,000	5,400	9,000	9,000	3	6	15,000 ft.
11. Chicago Junction.	5,000	—	5,000	9,000	—	—	—	—
12. E. J. & E.	4,100	—	4,100	6,000	7,000	3	3	237,000 ft.
Total	77,700	73,800	151,500	241,500	244,500	72	132	3,673,000 ft.

Fig. 3. Annalysis of Power Required by Various Railroads Entering Chicago.

These data are worked out for the same electrified zone that is being considered by the Association of Commerce Committee on Smoke Abatment and Electrification of Railway Terminals.

Under the centralized plan of power distribution, only 21 additional substations would have to be established. There is a saving in total power house capacity of centralization station, vs. individual power plants owned and operated by individual roads of approximately 100,000 k. w. There is also a corresponding saving in conduit and poll line construction as well as in feeder cable distribution systems.

PROGRAM 6TH ANNUAL CONVENTION, I. E. S.

Hotel Clifton, Niagara Falls, Ont., September 16 to 19, 1912.

1—Report of Committee on Progress. This report will deal with the recent progress and developments in the lighting industry both in this country and abroad.

2—A Report of the Committee on Nomenclature and Standards, which will deal with certain definitions and terminology of illuminating engineering.

3—"Steel Mill Lighting"—a report of the committee on illumination of the Association of Iron and Steel Electrical Engineers—to be presented by the chairman, Mr. C. J. Mundo.

4—"High Pressure Gas Lighting" by Mr. F. W. Goodenough, Chairman of Council, Illuminating Engineering Society, London, Eng.

5—"The Status of High Pressure Gas Lighting" by Mr. George S. Barrows. This paper will be a collection of domestic and foreign correspondence pertaining to high pressure gas lighting.

6—"Recent Developments in Gas Lighting;" by Mr. R. F. Pierce.

7—"Indirect and Semi-Indirect Illumination" by Mr. T. W. Rolph.

8—"Recent Developments in Series Street Lighting" by Dr. C. P. Steinmetz.

9—"Research Methods" by Dr. E. P. Hyde.

10—"The Problem of Heterochromatic Photometry and a Rational Standard of Light" by Dr. H. E. Ives.

11—"Reflection from Colored Surfaces" by Mr. Claude W. Jordan.

12—"Diffuse Reflection" by Dr. P. G. Nutting.

13—"A Study of Natural and Artificial Light Distribution in Interiors" by Mr. M. Luckiesh.

14—"The Physiology of Vision" by Dr. T. A. Woodruff.

15—"The Efficiency of the Eye Under Different Systems of Illumination" by Dr. C. E. Ferree. This paper will be a report of a research carried on for the American Medical Association.

16—"A Proposed Method of Determining the Diffusion of Translucent Media" by Mr. E. L. Elliott.

17—"Illumination Charts" by Mr. F. A. Beuford.

18—"The Determination of Illumination Efficiency" by Mr. E. L. Elliott.

19—"An Absolute Reflectometer" by Dr. P. G. Nutting.

20—"Colored Values of Illuminated Surfaces" by Mr. Bassett Jones, Jr. This subject will be presented in the form of a series of experimental demonstrations.

21—One session will be arranged for, a potpourri, at which discussions will be in order on miscellaneous phases of illuminating engineering. It is expected that this session will bring out interesting and valuable points not particularly covered by the above papers and reports.

Inspection tours of the power houses and other wonderful development enterprises peculiar to this location have been arranged for.

New Pennsylvania Diners

The efficiency of the dining car service on the Pennsylvania Lines has been increased by the adoption of a decided innovation in dining cars. By omitting platforms and vestibules, space has been provided for two additional tables, seating six people—making the capacity thirty-six people. What the new arrangement means is indicated by the fact that one of the first demonstrations of the car to determine its capacity for business showed that 108 people were served in three hours with no rush or crowding.

Fig. 1. Interior of Diner.

The new Pennsylvania dining car is 83 feet long over all; it is of all-steel construction, weighing 147,500 pounds. The kitchen is 19 feet 6 inches long, and the pantry 7 feet long. There are no platforms, every inch of space being utilized; side doors are provided at each end for stocking both the kitchen and the steward's department. A sliding door shuts off the kitchen and pantry from the main dining room, while fans at each end of the kitchen free the car of odors and smoke. The dining car is finished in French gray.

Fig. 3. Interior of Kitchen.

Fig. 2. Exterior of Diner Showing Vestibules Omitted.

Probably the most important new feature of the dining car from a service standpoint is the arrangement of the kitchen and pantry. The latter, with a special pantryman in charge, has a sink and soiled dish table, sherbet and cream cabinet, and chill boxes for keeping milk, cream, condiments, cut butter and fruits. This facilitates the work of the waiters to a marked degree.

The dining room is lighted by 7-50 watt lamps in the center deck and 24-15 watt tungsten lamps on side brackets as shown in the occompanying illustration.

The kitchen is also lighted by 3-50 watt units, these being placed in a row down the center of the ceiling as shown in the accompanying illustration.

Satin finished Holophane reflectors are also used here, and 60 volt straight storage equipment is provided for electric lighting.

Ventilation of Diners

The new combined blower and exhaust ventilator, as illustrated herewith, is a distinct step in the progress of railroad car ventilation. Although up to the present time it has been designed for use in dining cars only, a modification of this type can easily be worked out for ventilating Pullmans and even coaches. The exhaust type ventilator, known as the "Garland," developed six years ago, has proved very satisfactory in ventilating cars when the train is in motion, but fails to provide for ventilation when laying in the station or at other times when

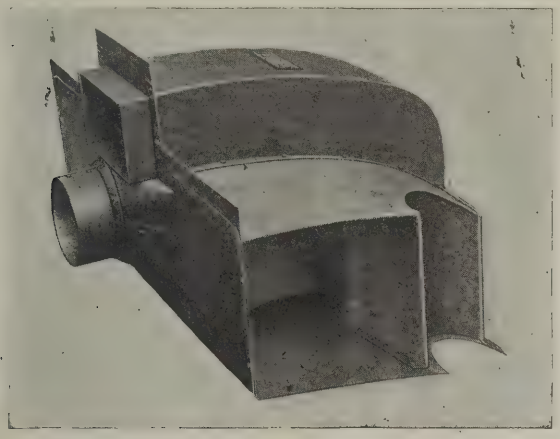


Fig. 1. Combination Garland Blower Ventilator.

the train is at rest. Hence, the new blower ventilator has been designed to overcome this difficulty.

The dining car, although not as difficult a ventilation problem as the Pullman sleeper, is one of the most urgent in all car ventilation. It is a foregone conclusion, that the place where we eat should be clean and fresh, but the smudge and smoke from the kitchen continually militate against this, and where no blower ventilation is provided and the cooks begin operations two or three hours before the train leaves the station, this may become a very objectionable feature. Moreover, in many cases the negro waiters sleep in the dining room and by the time the car is picked up next morning the air has become foul and, unless an effective system of ventilation be provided, is most offensive to the passenger entering the diner for his breakfast.

The combination blower and exhaust ventilator is a very desirable supplement to the standard ventilators. Its construction is shown fairly well in the accompanying diagram, although being made up very largely of curved surfaces, it is difficult to represent diagramatically. It should be noted that the new ventilator combines the action of a blower exhaust with that of the standard Garland ventilator without interfering with, or reducing the action of either type. As a matter of fact, the current of air driven through the ventilator while the car is standing still, actually induces an added flow of air through the unrestricted opening of the Garland type ventilator. This increases the efficiency of the blower about 15 per cent.

This is accomplished by means of a curved lip, shown as a dotted line in Fig. 2, which, as the exhaust from the blower is driven against it, creates a whirling motion in the exhaust, which draws the air through the opening above.

When the train leaves the station, the ventilator begins to act and increases the blower exhaust, but upon reaching critical speed of the generator equipment, the motor of the blower is automatically cut off and the blower ceases operation. Thereafter, however, until the next stop, a very effective ventilation is maintained by the Garland ventilators. Upon slowing down at the next stop, when the automatic switch opens, the blower will immediately become operative and will continue to work until the train leaves that station and again attains critical speed of the generator equipment.

It will be noted from the accompanying table of exhaust values, that each blower ventilator unit alone, in both kitchen and dining room, exhausts 33,000 cubic feet of air per hour, a total of 66,000 cubic feet for the whole

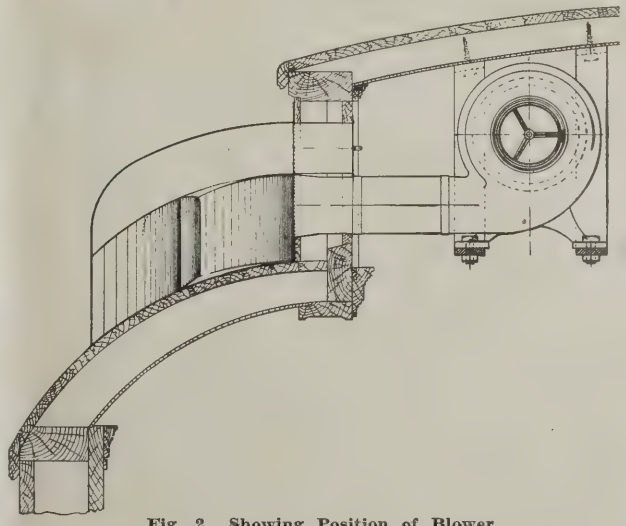


Fig. 2. Showing Position of Blower.

car. This is sufficient to maintain a fairly good ventilation, when the car is at rest. When the train gets up to a speed of 50 miles per hour it should be noted that with the standard Garland ventilators 140,000 cubic feet per hour are removed from the dining room and 100,000 cubic feet from the kitchen, a total of 240,000 cubic feet of air removed per hour at that speed.

Although the capacity of the kitchen is only 600 cubic feet, while that of the dining room is 2,600 cubic feet, there are 5 exhaust ventilators installed in the kitchen, while there are but 7 in the dining room. This provides that there will be a constant flow of air toward the kitchen, so that the kitchen odors cannot enter the dining room.

The blower in both kitchen and dining room is mounted as shown in Fig. 2. In the dining room, however, this is placed directly over the passage way in front of the buffet and ventilates from a decorative screen located in the arched panel over the passage way. This being placed midway between the dining room and kitchen, prevents gases which may not be caught by the kitchen blower from reaching the dining room.

The blower as employed in this unit is a special railway car ventilating blower, manufactured by the B. F. Sturtevant & Co., and is designed so that both motor and bucket wheel may be easily removed for inspection and cleaning. A packed bearing is being designed to replace the oil-cups shown in the accompanying illustration.

The facility with which the bucket wheel may be cleaned is an important consideration in every dining car ventilating system, for the exhaust passing through the blower is heavily laden with greasy steam and particles of carbonaceous matter which collect on the bucket wheel.

Result of Tests.

Dining room equipped with 7 Standard Garland Exhaust Ventilators, train running.

Speed-Miles Per Hour	No. of Vents	Exhaust Cu. Ft. Per Hour	No. of times air changes per hour	Time in whch air is completely changed
25	7	70,000	26.95	2.25 min.
30	7	84,000	32.25	1.86
40	7	105,000	40.38	1.48
50	7	140,000	53.85	1.11

Average air capacity of dining room is 2600 cubic feet.

Kitchen equipped with 5 Standard Garl and Ventilators, train running.

Speed-Miles Per Hour	No. of Vents	Exhaust Cu. Ft. Per Hour	No. of times air changes per hour	Time in which air is completely changed
25	5	50,000	83.33	.72 minutes
30	5	60,000	100.00	.6
40	5	75,000	125.00	.48
50	5	100,000	166.66	.36

Average air capacity of kitchen is 600 cubic feet.

Auxiliary Blower Alone.

	Cu. Ft. of air drawn out per hour	No. of times air changes per hour	Time in which air is completely changed
In Dining Room	33,000	12.7	4.7
In Kitchen	33,000	55.	1.09

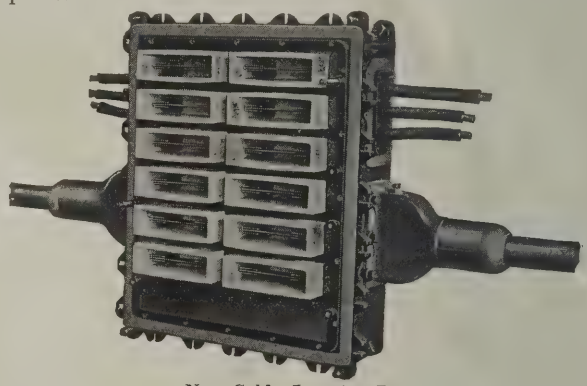
A NEW CABLE JUNCTION BOX FOR HIGH TENSION TRANSMISSION CIRCUITS.

A new type of cable junction box suitable for the inter-connection of high voltage feeders and mains is shown in the accompanying illustration. This is the first high voltage junction box made in this country, we believe. It will be noted that the flexible leads which project through the sides of the box are so arranged as to terminate within the large removable nipple. These nipples have a rounded or dome-shaped end made entirely of soft metal such as lead or lead-tin alloy. This dome-shaped portion is united with that portion of the nipple which is of brass or other rigid material by an exceedingly strong and absolutely water tight joint. The leads are connected to the outermost contact points of each row of disconnecting switches, the innermost point being connected to bus-bars, giving the desired interconnecting arrangements.

The exposed live parts—that is, those shown in the cut, are isolated in cells of porcelain so that the disconnecting blades can be inserted or removed permanently fastened in a metal framework, which, in turn, is fastened to the box, in such a manner that a chamber is formed between the framework of cells and the bottom and sides of the box.

This chamber, after the carrying parts that enter it are put in place and insulated with tape, when desired, and after the moisture has been removed by the heat and vacuum process, is filled with a hot insulating compound. Insulating stuffing boxes prevent the compound from oozing out along the flexible leads when the box again warms up under working load. The concealed current carrying parts of this box are, therefore, assembled and insulated before the box is sent out from the factory, where the work can be done with the greatest care by operators skilled in that particular work under expert supervision.

In order to make the cable connections, all that is necessary, is to unbolt the nipple from the box, cut off, with a saw or jack knife, the dome-shaped end of the soft metal portion of the nipple and, after threading it over the table, joint the conductors to the insulated flexible lead. After this the nipple can be replaced, the joint wiped and the space within the nipple filled with hot OZITE insulating compound. The connection is then complete.



New Cable Junction Box.

These boxes have been used considerable quantities on circuits of 4500 volts working pressure for a period of nearly two years with satisfactory results. In other installations they are operating at 5000 volts. The same general design is suitable for still higher voltage.

An interesting reference to the box and its use in one of the largest underground systems in the United States (that of the Pacific Gas & Electric Co.) is given in the April Proceedings of the A. I. E. E. in a paper by Messrs. Lisberger and Wilson. These boxes were originally designed to meet the needs of Mr. Lisberger who is chief engineer of the P. G. & E. Co., and who cooperated with the manufacturer in bringing the design to its fruition.

This box is protected by U. S. Letters Patents and is manufactured by the Standard Underground Cable Co., of Pittsburgh, Pa. It presents some new and interesting features which make for greater flexibility and convenience in this class of equipment.

FURTHER IMPROVEMENTS IN HOLOPHANE.

A new standard line of high efficiency reflectors will be offered shortly by the Nelite Works of General Electric Company. The new line will be known under the trade name of "Xtraficiency" and will not only be of considerably greater efficiency than present standard line Holophane reflectors, but are claimed to be the most efficient lighting glassware in the world. Electrical Testing Laboratories, photometric tests will be offered to substantiate this statement. In announcing the new line, Mr. W. F. Minor, in charge of the efficiency glassware sales of the Nelite Works, said:

"Now that we are in position to sell every type of illuminating glassware, we realize the distinct position of each type. At one time, the industry undoubtedly lost its head over Holophane—that is to say, the efficiency and ease of installation of our product was such that Holophane glass was frequently used in places where another type of glassware might have served to

better advantage. The natural result of this over-enthusiasm for high efficiency glass led in time to an equally erroneous prejudice in favor of opal glass, so that today we see many installations equipped with our own opal or others which might better have been equipped with Holophane.

The new "Xtraficiency" line of Holophane glassware will help to define the proper place for each class of equipment. Where efficiency is the chief consideration, Holophane is without doubt the proper equipment. As decorative necessity or architectural restrictions call for more decorative glassware, the opals find a natural place. I think that in future we will not see prejudice in favor of any particular type of lighting equipment carried to the lengths it has been carried in the past, and that the glassware selected for each installation will be selected with a view to the exact requirements of the case and not in accordance with the ready-made arguments of the man making the installation."

Thermostat Temperature Control for Railway Cars

A new thermostatic heat regulating device for controlling the operation of the train heating system shown herewith, seems to have many points of merit. The rise of the mercury column in a thermometer is employed to make an electrical contact at a certain temperature which allows the current to flow through an electrically operated valve. It may be readily operated from any electric lighting circuit on a car of the standard voltages and can

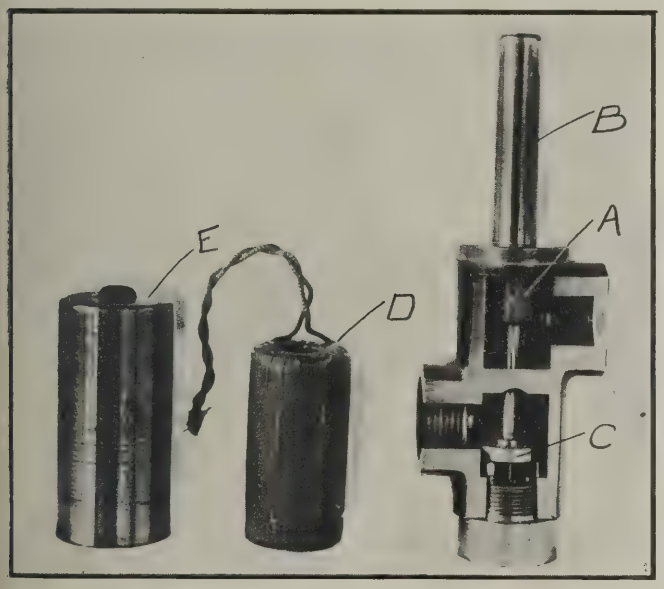


Fig. 1. Dissembled Parts of Magnetic By-Pass Valve.

A. Norway Iron Plunger, Copper Plated; B. Sealed Brass Shell Enclosing Plunger; C. Valve Connected by Stem to Plunger; D. Removable Lifting Coil; E. Iron Casing for Coil.

be used to control the operation of any heating system now in use whether high pressure steam, vapor steam, or hot water heat.

Platinum wires are fused into the tube of a standard thermometer at various temperatures from 60° to 74° and plug contacts are provided so that the equipment may be set to operate at any given temperature as shown in Fig. 1. As the mercury in the thermometer column rises it makes contact with the platinum wire, at the temperature setting of the system. A weak current flowing through this mercury contact inside of the thermometer operates either a solenoid valve or a motor operated valve as the case may be, and cuts off the flow of steam through the heating coils. There upon the car begins to cool off and the mercury column in the thermometer falls and breaks contact at the temperature setting of the system. When this occurs either motor or solenoid valve will immediately operate to again turn on the steam.

In this way the temperature within a car may be maintained constantly at any desired point without requiring any attention on the part of the train crew. The solenoid by-pass valve as shown herewith is designed particularly for vapor steam or hot water heating systems. It consists essentially of a by-pass valve, the stem of which is connected to the plunger of an electro-magnet. This plunger is heavily copper plated to prevent rusting and is entirely incased within a brazed brass shell so that no

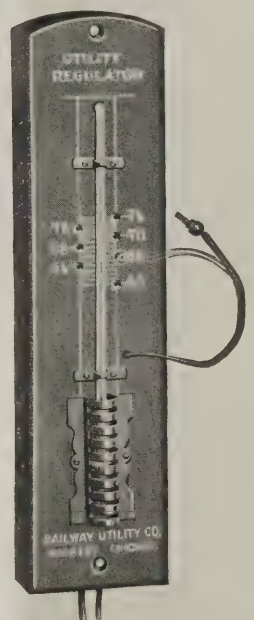


Fig. 2. Regulation Thermometer.

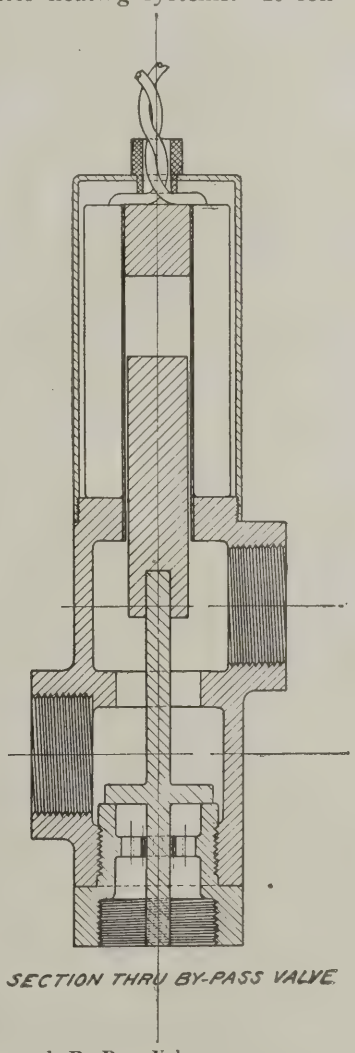


Fig. 3. Section Through By-Pass Valve.

stuffing box is required and there can be no leakage of steam or water. The lifting coil B is placed directly over this enclosing tube and an iron casting A placed over it both for purposes of protection and to provide for magnetic circuit of the coil. The coil is removable as shown in Fig. 1. This makes coil maintainance and repairs a simple matter. The coil is very substantially made of enamelled wire and is not affected by the heat of the steam.

A Multiple Spring Belt Fastener

With the greatly increasing number of axle equipments in service, means and methods of reducing costs of operation are becoming of far greater importance than in the earlier days when there were but few equipments in service. Belt troubles have been one of the big items of expense and it is probably true that about 75% of all belt trouble is due either to improper alignment or careless work in applying the belt, which causes the belt to ride the flanges and be cut to pieces, or the belt cracks at the fastener and tears apart at that point.

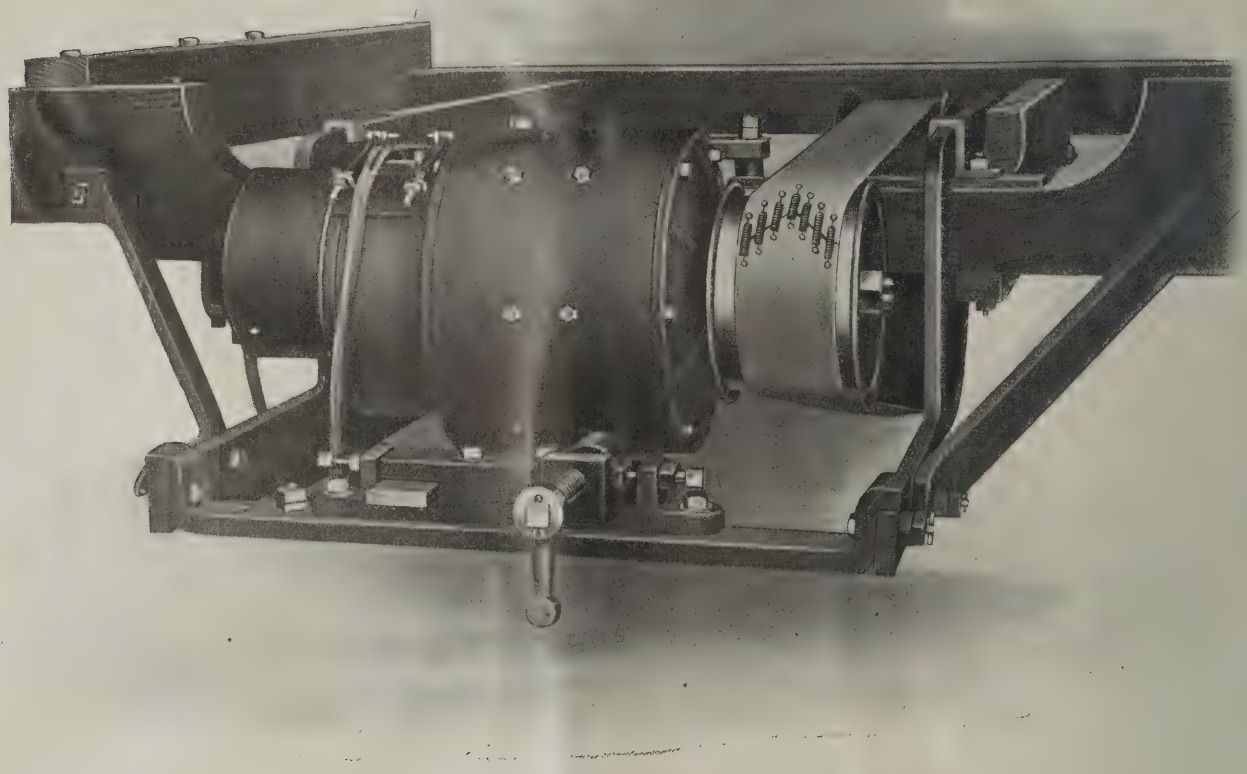


Fig. 1. Showing New Consolidated Rigid Suspension with Spring Belt Fastener.

The new spring belt fastener recently developed and shown for the first time at the Atlantic City Conventions by the Consolidated Ry. Elec. Lt. & Equipment Co., is of interest to all operators of axle equipments. Its construction is clearly shown by the accompanying illustration, and it will be noticed it is merely 7 small springs holding the two ends of the belt together. By means of a screw adjustment, the dynamo is drawn out from the truck, until the belt is tight and the ends of the belt have separated about 5/8 of an inch. Any stretch that occurs in the belt, is automatically taken up by the spring fastener until the ends of the belt get close together, when the dynamo is again drawn out by means of the screw. A total of 8" stretch is provided for, but it is doubtful if so much is necessary, on account of having less tension on the belt than formerly, and there being less liability of the belt to stretch. The splice is made in the form of a V and all the springs are fastened to one end of the belt in the shop, where a careful job can easily be made; here too the holes to receive the rivets for connecting the springs to the other end of the belt, when it is applied to a car, are punched in a special little hand punch which insures that the springs be all properly aligned

The rivets are provided with a barb, which prevents their falling out of the holes, while the belt is being handled or applied. The fact that the rivets are clinched on top, leaves no doubt as to the security of the rivets, which is a distinct advantage over the method of riveting, where the clinching is done on the under side of the belt out of sight of the operator.

Since the spring fastener will maintain a uniform belt tension of known value and will also take up any belt stretch which occurs, it becomes unnecessary to have any generator take-up spring. The generator can then be mounted on a rigid base and generator suspension troubles reduced to a minimum.

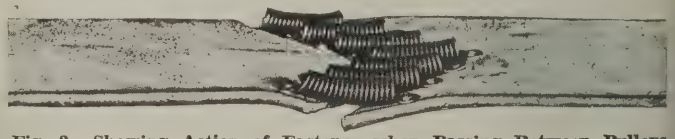


Fig. 2. Showing Action of Fastener when Passing Between Pulleys.

It will be noted from Fig. 2 that when the fastener passes between pulleys it retains practically the same belt curvature right at the joint, as when engaging pulley. This is caused by the eccentric position of the fastener and at a first glance might be considered as an objection to this type of spring fastener. As a matter of fact, however, this is a very great advantage and should tend to prevent cracking of the belt. All warping and bending, as the fastener engages a pulley, is taken up entirely in the springs themselves and the belt in the immediate vicinity of the joint retains practically the same curvature at all times whether on the pulley or not.

Aside from its other advantages, it permits the dynamo being made rigidly fast to the truck, thus doing away with the rapid wearing of moving suspension parts, and at the same time placing part of the weight of the dynamo on the end sill, instead of the whole weight outside on the suspension irons themselves.

Lesson No. VII.

Installing Axle Equipments

The methods by which axle equipments are installed on railway cars may vary in certain details and the same result may be often accomplished in two or three different ways. By presenting some of the various methods, however, it may be possible that our readers will find in these some suggestion whereby they may be able to simplify their own methods.

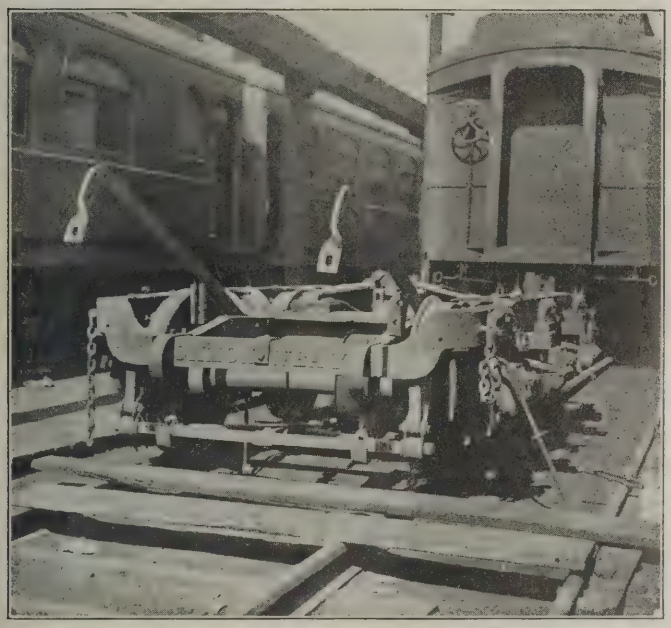


Fig. 29. Truck Run Out and Side Irons Blocked Up.

The generator is the heaviest part and most difficult to install properly. Some roads go to the trouble of raising one end of the car and running the truck out when it becomes necessary to install a generator and suspension, while other roads will not go to this trouble. But with six to eight holes to drill into a steel truck, the application of a generator and suspension, with the car body on the truck, requires some strenuous work by three men for about 9 hours. While on the other hand, to raise the car and run out the truck takes no more than one hour's time of four laborers. With the truck out where the men can work at it conveniently, it should not take longer than five hours for three men to completely install both generator and suspension. Another point in favor of running out the truck is, that when this is done it becomes possible for each gang of three men to equip two cars per day.

For the above reasons it seems advisable for car lighting departments of the various roads to insist on cars being raised and trucks run out when it is necessary to install a generator with suspension on a steel truck.

Mounting Generator.

Fig. 29 shows the truck run out from under a car with the side irons raised so that the dynamo may be left in position. The suspension loops are applied to the generator in the shop and the generator with loops is brought out on a two wheeled hand truck, as shown in Fig. 30. The planks laying across the track on which the truck is run are about the right height to bring the generator into proper position. The saddle irons are then placed on the side irons and suspension loops with spacing rods bolted into place, as shown in Fig. 31. It will be noticed that the hole near the threaded end of the spacing rod is made oval. This is so that if the suspension loops hung in the saddle straps wear slightly, they will not bind on, or break the threaded spacing rod.

Some trouble has been experienced with the holes of the suspension loops wearing down and breaking this rod, but they are now supplied with a removable bushing, so that it is only necessary to remove the bushing instead of the entire suspension loop as formerly.

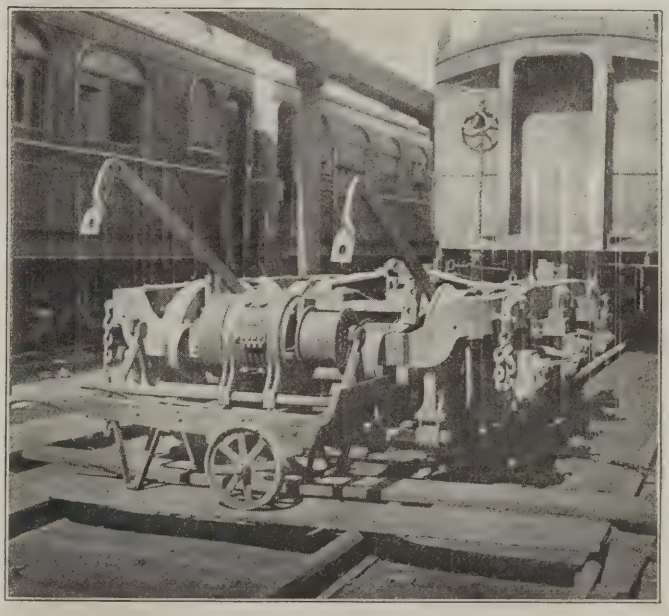


Fig. 30. Dynamo Wheeled into Position.

Whenever it is impossible to run out the truck, or it is considered inadvisable to do so, it is necessary to remove the generator from the hand truck on which it was brought from the shop and slide it in bodily under the truck on planks. It is then jacked up into place, either by jack screws or crow bar with blocking. Suspension loops are then properly connected as described above.

In bringing the generator from the shop on a two wheeled hand truck, it is a good scheme to bolt it securely to the truck at each end of both suspension loops. Otherwise, in crossing over rough planking between trucks the generator may become overbalanced,

and in falling off the truck either hurt some of the men or damage itself. It will take all three of the gang to properly handle one of these generators on a truck, one in front at the handles and two in the rear.

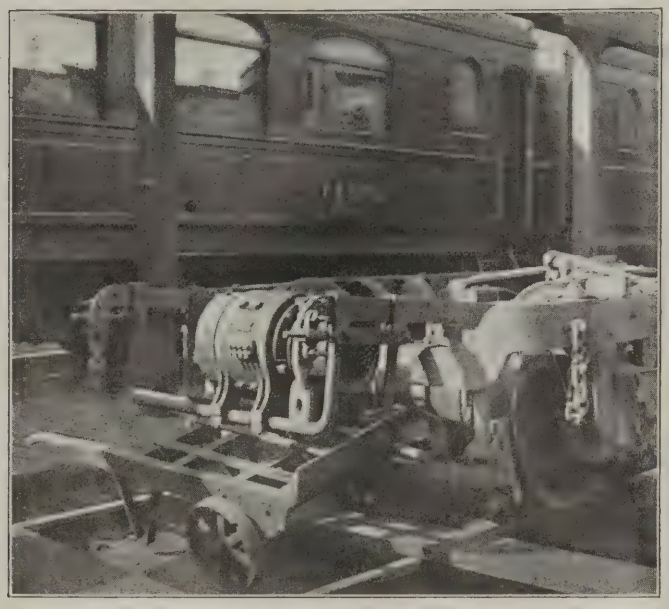


Fig. 31. Side Irons Connected to Loops.

Alignment.

In order for a belt to run true on both axle and armature pulleys, the axle of the generator must be parallel to the car axle, and the center of the axle pulley face must line up with the center of the armature pulley face.

The first step after the generator is hung on the suspension is to mount the axle pulley on the car axle, so that it will line up with the armature pulley. To do this, lay off on the end sill the dimension "A," Fig. 32,

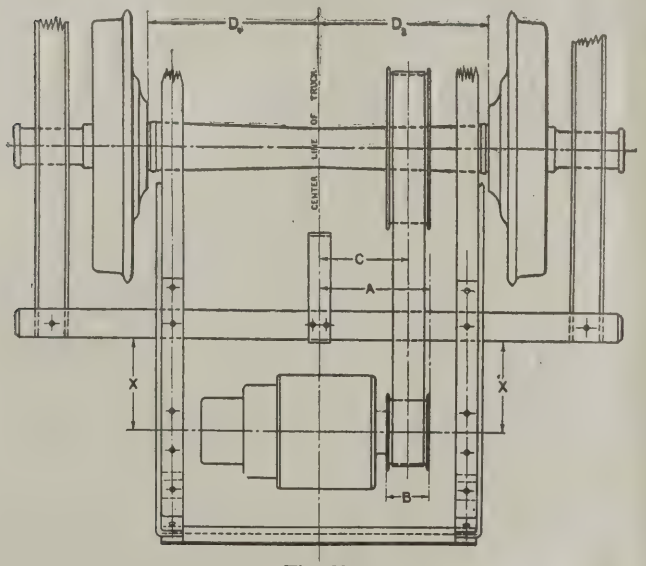


Fig. 32.

by laying a straight edge across the outside face of the armature pulley and measuring to the center line of the truck. By subtracting half of the armature pulley face "B" we get the dimension "C," from center line of truck to the center of the belt in proper position. Then measure the distance between hubs and mark a point on the axle midway between with a center punch. The axle pulley is then set so that the distance from the face of the pulley to the point on the axle, plus ½ of the axle pulley face, equals dimension "C."

The next step is to get the generator axle parallel to the axle. Measure to the face of the end sill after the belt has been applied and brought to proper tension, and adjust either end of generator suspension until dimension X, Fig. 32, is the same as X′.

It is usually impossible to measure to the axis of the generator, but by measuring from the end sill to face of the armature pulley and adding ½ the diameter of the pulley, you can determine X′; then simply by measuring to the face of the generator housing and adding half of the diameter of the housing you can measure X and make it equal to X′.

Another rough and ready method, which is much more simple and probably accurate enough for practical purposes is obtained by simply sighting with the eye and moving the axle pulley center in line with the armature pulley center. There is a lateral play of ¾" of the axle in the journals and this must be taken into account when lining up in this way. It is necessary to open the journal boxes and measure the distance from collar to journal on both ends of the axle. It will usually be found that the collar is tight at one end and open ¾" at the other. Figure, then, to set the axle pulley ⅜" nearer to the open end of the axle.

The generator is set parallel to the end sill as before.

Fig. 33. Installation Finished.

Applying Belt.

Since the Crescent Belt Fastener is probably more universally used than any other, we will confine ourselves to that particular type, at present; later, however, will devote a whole lesson to the subject of "Belts and How to Apply Them."

After passing the belt over armature axle pulley, bring the two ends together, keeping the edges even and make the joint tight. The rivets should then be driven into the belt backed by a block of wood, so that each rivet comes through the belt properly. Then lay the joint over the armature pulley and hammer down the rivets good.

The rivets should be tapered slightly toward the joint, *not* away from it. This may open up the joint a trifle, but when tension is brought on the belt, the rivets being tapered slightly toward the joint will act somewhat like hooks and the belt will bear against the entire length of the rivet. Whereas, if the rivets are tapered away from the joint, the tendency will be for the entire strain to

come at the tip of the rivet, which has been bent over in applying, causing them to pull right out.

The rivets should be just long enough to project about ⅛ of an inch through the belt for clinching. If they are longer than this, these long ends will wear down thin in service and tend to cut the belt like knives. Rivets of proper length, if tapered slightly toward the joint, will give far greater holding power than the long rivets tapered away from the joint.

The axle belt should be cut squarely at both ends and to proper length and the fastener applied to one end in the shop. This saves considerable time and much more satisfactory job can be done on that one end at least.

Probably one of the greatest causes of failure of axle equipments is due to improperly applied belts. A belt, carefully put on, will unquestionably run about twice as far with half the attention than a belt carelessly applied, so that a few minutes more spent in doing this job carefully is a mighty good investment.

Next month we will take up the subject of "Regulators. Their Installation, Adjustment and Some Operating Stunts."

(Lesson to be Continued Next Month.)

UTILITY EXHAUST VENTILATOR.

The new Utility ventilator for exhausting foul air from the roof of a car which is illustrated herewith seems to be of effective design. As the car moves through the air at high speed, air currents will be developed in the outer ring of the ventilator which will induce a flow of air through the exhaust pipe of the ventilator as shown by the arrows. This ventilator will operate with equal facility whatever the direction of train motion be. In fact, even a moderate wind from any direction when the car is standing still will effect a considerable exhaust through the ventilator.

This ventilator was designed specificially with the idea of eliminating troubles from rain and cinders. It will be seen from the diagram that it is practially impossible for cinders, dust or rain to get into the ventilator and

Showing operation of Utility Exhaust Ventilator.

practical experience as proven this to be the case. 2000 of these ventilators are being installed as shown in the accompanying diagram on some new steel cars being built by the American Car and Foundry Co., by the Illinois Central.

Ventilators are made in all sizes and special lamp jacks for oil and gas lamps are interchangeable with the older types. They are found to be especially advantageous in this service as they keep out both water and cinders very effectively.

This ventilator is made by the Railway Utility Company of Chicago.

A. I. TOTTEN GOES TO BRAZIL.

Mr. A. I. Totten, well known among the railroad men as manager of the railway power sales of the Chicago office of the General Electric Co., has just accepted the position of Assistant in Charge of Mechanical Affairs of the Brazil Railway Co., with headquarters at Sao Paulo. Brazil. This position corresponds to that of Assistant General Superintendent of Motive Power in this country, and Mr. Totten will have direct charge of all electrical matters on the railroad.

The place he is going to is of about the same latitude in the southern hemisphere as Cuba, is a place of per-

A. I. Totten.

petual summer and of high altitude, 3,000 ft. The Brazil Railway operates about 3,000 miles of line.

Mr. Totten was with the Southern Railroad five years, and held the title of Shop Engineer. He then went with the Queen and Crescent as Electrical Engineer for two years, with the Sea Border Air Line as Electrical Engineer for two years, after which he entered the employ of the General Electric Co., as Manager of the Railroad Power Department of their Chicago office.

He sails August 20 and while all of his railroad friends in the middle west and elsewhere wish him the best of success, we feel that we are losing a good man and an enthusiastic worker in all Association affairs.

Here's hoping he won't stay down there very long.

C. & N. W. RAILWAY GO TO 60 VOLT OPERATION.

The Chicago & Northwestern Railway are changing the last of their headend systems from 110 volt to 60 volt operation. On August 5, all trains will be equipped for operation at 60 volts in accordance with the standards recommended by the Association of Railway Electrical Engineers.

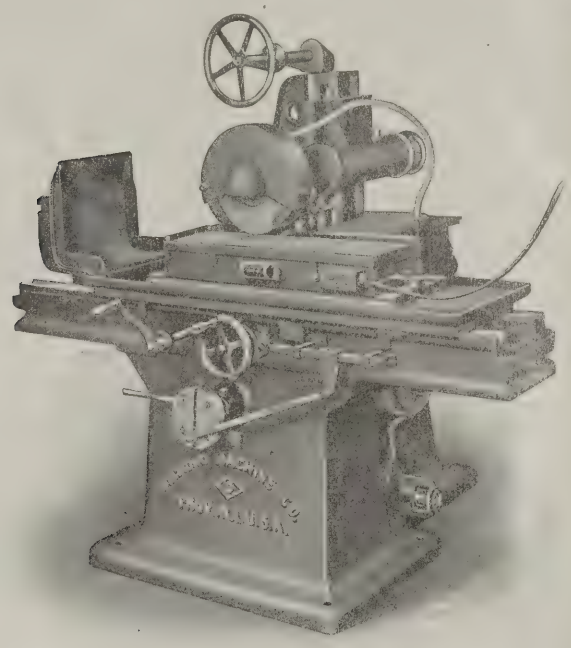
The new Chicago Terminal of the C. & N. W. Ry.. as described in the August, 1909, issue of the *Railway Electrical Engineer,* contains a provision for lighting the trains from the station power plant while laying in the

terminal. All the station wiring is on a three wire, 110-220 volt system.

The conversion of the train lighting systems from 110 vole to 60 volt operation therefore has required the installation of two 50 k.w. motor generator sets 110-60 volt, which may be operated in connection with the three wire system either in series or parallel as required.

D. & W. MAGNETIC CHUCKS.

Among the many labor saving devices which the application of electricity as motive power in railway shop practice has resulted in, the magnetic chuck seems to be one of the most ingenious. It possesses a very wide

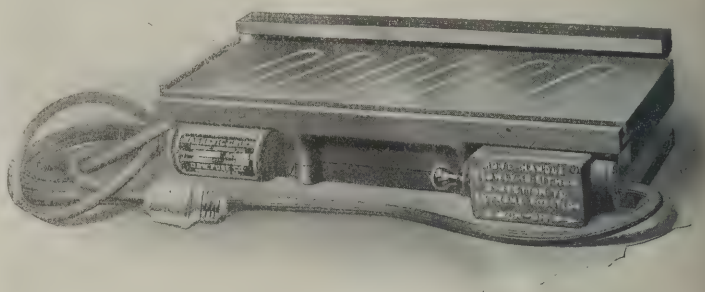


Magnetic Chuck Mounted on Surface Grinder.

range of usefulness in holding steel and iron pieces for grinding, planing, shaping and milling. It is manufactured in the horizontal flat bed, verticle and rotary types.

The flat chucks have a horizontal face and are equipped with adjustable end and side stops, providing convenient means for locating and steadying the work on the surface of the chucks. They are particularly useful in holding work for grinding, such as file blanks, scale blanks, thickness gauges, punches, dies, knives for wood working machinery, accurate skins, gibs, or practically any work on which it is necessary to grind flat surfaces. Thin stock can be held for grinding on one face without the distortion due to clamping the edges.

Milling operations can be performed with great facility where the shape of the work is such that the end stop of the chuck can be raised to take part of the thrust. When used in this way the smallest flat chuck will hold a 1 in. x 2 in. x 6 in. bar of tool steel strongly enough



Detail of Magnetic Chuck.

to mill .050 in. off the surface 2 ins. wide with a feed of 1 in. per minute.

The rotary chucks are especially adopted for grinding pistons, and piston rings to fit the ring grooves with the utmost accuracy.

The magnet coils are wound with Deltabeston Wire, having a special heatproof insulation of pure asbestos. This insulation can safely withstand temperatures as high as 400 Fahr. In addition, the coils are wound by a special process which still further protects them from heat and moisture. The coils are rigid units which are interchangeable, and the construction of the chuck is such that they can be readily replaced by any intelligent workman. This obviates the necessity of returning the chuck to the factory in case of injury.

These chucks are both oil-proof and water-proof and are equipped with demagnetizing switches for readily releasing the work.

REMY ELECTRIC SALES.

The Remy Electric Company, Anderson, Ind., makers of high power electric headlights for locomotives, sold 40 equipments to the Rock Island Railroads recently.

NEW U. S. L. BULLETIN.

The U.S. Lt. & Htg. Co., distributed a little booklet at Atlantic City Convention describing their new type S. 1. regulating panel and type C4. lamp regulator. A copy of this booklet will be gladly forwarded to any one interested upon postal card request.

EFFICIENT MANAGEMENT IN YOUR SHOP
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And bringing your equipment up to a high standard of economical, reliable operation.

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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Trial Tests.

Almost everything that is now used in railroad service, and a multitude of other things that are not, have been "tried out" on one or more roads when they were first developed. Some of these pass this practical service test with flying colors, while others that really have considerable merit, fall down miserably. Some railroad men seem to have the idea that when they make a test, the sole purpose of that test is to make the equipment fail if possible.

Now, there is nothing perfect and nothing under the sun which will not fail under certain conditions. While this spirit of almost encouraging the device to fail may be of actual service in showing up its weak points so that they may be remedied, the failure of a single device when it is being so tested should not be in any way taken as a final condemnation.

It should not be necessary to fuss and tinker with a device on test, but that device should be given at least the same inspection and care, yes, and repair, if necessary, that you would give any similar device in operation on your road. Many a good device is in desrepute with certain railroad men, simply because it "fell down" on a single trial test in which it was given no inspection or care whatever, and in which it may have been improperly applied in the first place, often times showing gross ignorance of the device or carelessness on the part of the installer, or probably both.

Where it is possible to do so, it gives a much more correct idea of the operation of any device to test three of four, or even a half dozen samples instead of baseing your whole judgment upon the operation of one lone sample.

Give these tests the same care, and for your own information, even better inspection than you do your standard equipment and you will not only be giving the manufacturer a square deal, that's the least of it, you may be assisting in the development of a device which will not only better your own service and decrease your own operating costs, but those of every other railroad in the country as well.

High Candle Power Lamps vs. Low.

Since the development of the tungsten units of higher candle power, many arguments have been advanced for their use in replacing clusters and smaller single units at more frequent spacings, both on account of the lower first cost, lower maintenance and higher efficiency.

In railway service, however, there are other considerations which enter into the problem that alter it materially. It is very often necessary to light small shops, stations, yards, etc., in outlying districts, which are far from any store house, and where high wattage lamps are used in place of clusters, it is not usually considered advisable to have a reserve supply of the larger and more expensive lamps on hand. Then when one of them burns out it will leave a considerable shop area in darkness and this will not be taken care of until another lamp is received from the store house, which may take a day or two. With three or four light clusters used in such places, a burn out of one lamp will not materially affect the ilumination, and these burnouts can be replaced periodically by the electrician from headquarters.

In railroad practice it would then seem that the question resolves itself into one of reliability rather than one of economy in first cost or economy in maintenance. Where it is possible to maintain a supply of high candle power lamps on hand at all times to immediately replace bournouts as they occur, the higher power lamps are generally to be preferred, but in the many shops, round houses, stations, etc., in remote districts, three or four light clusters will probably give much more reliable service than the same wattage in a single high power lamp.

Clean Lighting Fixtures.

The importance of keeping lamps and reflectors clean is emphasized very strongly in the paper by Mr. C. E. Clewell entitled "Industrial Illumination" which is published in this issue.

This shows a reduction in illumination in one type of building of 50% in 24 days. This is for large shops with open girder type roof construction, and no ceilings. With other types of shops which have ceilings either low or high, the effect of dirt accumulation on lamps and reflectors seems to be somewhat less. This however, is about what would be expected, for with the open girder type roof construction, where there is no ceiling above the lamps, all the effective illumination downward must come direct from the light unit or reflector itself, and any collection of dirt thereon will greatly influence the efficiency of the lighting system. Any comparatively light ceiling which acts as a background for the lighting unit becomes an important factor in producing effective illumination on the floor. Dirt accumulates more slowly on ceilings than it does on lamps or reflectors, and the

intensity of light reflected per unit of area is very much less, so that that part of the effective illumination which is due to reflection from the ceiling remains more constant than that from the lighting unit itself.

Assuming a power cost of 2c, and cost of cleaning a 100 watt lamp with reflector at 3.c and 8 hours of lighting per day, curves are deduced which show that in high shops, where there is considerable dust and no ceilings, lighting fixtures should be cleaned every 12 days. In factories or shops with medium high ceilings, every 16 days, and in shops and offices with fairly low ceilings 25 days.

In erecting shops where the lighting units must be placed so as to clear the traveling cranes, the matter of cleaning might be considered a rather difficult and expensive one as the lamps are often cleaned from the cranes. Recent developments in lamp hangers specially designed for tungsten units have been made, however, and these operate without any jar, lowering the lighting unit right down to the shop floor, where both lamp and reflector can be properly cleaned.

Judging from the way things look at the present writin gour Fifth Annua lConvention is going to be the biggest and best Convention in the history of the Association.

Convention News.

Secretary Andreucetti reports that there will be some excellent committee reports made, and in addition, there will be some good papers presented by some of the leading authorities in their respective lines. One of these is to be a talk on the general subject of electrification by Frederick Darlington of the Westinghouse Electric & Manufacturing Co. Mr. Darlington has given a great deal of study to the subject of eelctrification, and is one of the best qualified men in the country to speak on this subject from a general point of view.

Entertainment.

The Entertainment Committee have planned a full week of entertainment for the ladies which is briefly outlined as follows:

MONDAY, OCTOBER 21.

8:30 P. M.—Informal Reception and Dance. Assembly Hall, 9th Floor Auditorium Hotel.

TUESDAY, OCTOBER 22.

2:30 P. M.—Automobile Tour about the City. Tour will start from the Auditorium oHtel at 2:30 sharp, and all ladies holding badges are invited.

8:30 P. M.—Ladies' night for viewing Exhibits.

WEDNESDAY, OCTOBER 23.

2:15 P. M.—Matinee Theatre party for all lady guests of the Convention.

8:30 P. M.—Some special entertainment stunts.

THURSDAY, OCTOBER 24.

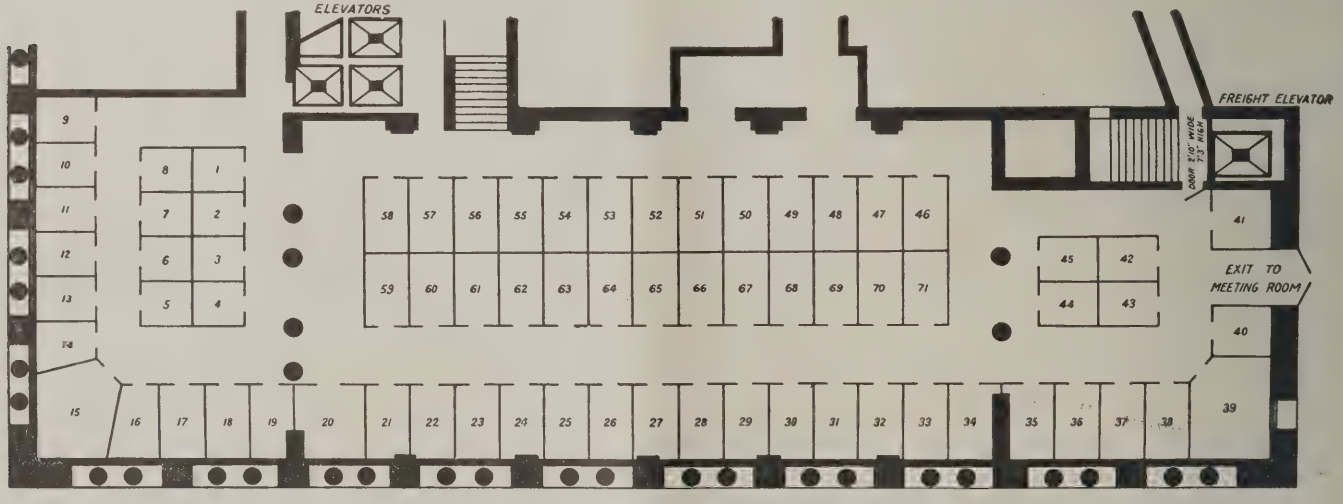
7:00 P. M.—Fifth annual banquet in the Gold room of the Congress oHtel. This is the finest banquet hall in Chicago, and George Porter, Chairman of the Entertainment Committee tells us that he has arranged with Mr. Frederick P. Vose to act as toastmaster. We all remember what a star performance he gave us last year, and now that he is an old friend of ours we feel safe in saying that anybody who misses this annual banquet will be passing up one of the best laughs of his life.

After the eats and the toasts the deck will be cleared for action, and the annual ball of the Association will occupy the rest of the evening.

Exhibits.

Last year we didn't have enough space to accommodate all exhibitors, so this year we have had to move to larger quarters. We have reserved the big exhibit hall on the 9th floor of the Auditorium Hotel, and will have about 25 per cent more space than last year. This is shown in the accompanying layout, and space is awarded at 45c per square foot. Communications regarding same should be addressed to Mr. W. F. Bauer, Chairman Exhibit Committee, 1013 Peoples Gas Bldg., Chicago. The Convention Assembly hall is immediately adjoining the exhibit room as shown in the accompanying diagram.

Better mark your calander and lay your plans now to attend this Convention. This is *the* big time of the year for the electrical departments of the railroads.



Shop Motor Talks.

Beginning with this issue we will publish in our shop section a series of motor talks going into the fundamental principles of some of the more important types of motors so that the men having these motors in charge may have more than a superficial understanding of their operation. It is a good thing to know why it runs and to understand characteristics in order to know in advance how a motor should act under certain conditions, and what kind of a motor is most suitable to perform certain duties.

The series will cover the principles of the various types of motors, both alternating and direct current and a description of the necessary controlling apparatus for each type.

The A. B. C. Car Lighting Series seemed to meet with such hearty approval among the car lighting men, that we feel that it will be well to extend this car lighting course so as to cover the shop motor field also, in the belief that many will be interested in that phase of the subject as well as car lighting.

New Diners for Illinois Central R. R.

The order of 114 new cars for the Illinois Central Railroad as reported in our 1912 issue are now being received by that company in lots of about a dozen weekly. One of the new diners is illustrated herewith, and it should be noted embodies the most improved type of construction in every detail. The car is electric lighted throughout, no auxiliary being supplied. The type of fixture used is one of artistic lines and of very recent design. In the paper presented by Mr. L. Schepmoes of the Safety Car Heating and Lighting Company, before the semi-annual convention of the Association of Railway Electrical Engineers at Atlantic City, this fixture was considered one of the most artistic and efficient of any of the modern types.

Fig. 1. Night Illumination in Diner. Note Arched Type Roof Construction.

A special Holophane prismatic reflector is used with a prismatic distributing bowl closing up the bottom. These are both mounted in a substantial and artistic bronze casing, and are both arranged so that they can be easily installed or removed.

The dining room is lighted by 5 large units in the center of the ceiling as shown in the accompanying illustration, and there are 10 small side bracket units each containing a 15 watt tungsten lamp placed over each table. These small units are of the same design as the larger center deck units both in reflector, prismitic, bowl and metal parts. They seem however, to be of a slightly more squatty form and hardly retain the same graceful lines which are so pleasing in the larger unit. Moreover, the position of the lamp is so near the wall, about 5 in., that a large amount of light from these units is lost on the art glass and window curtains. They are presumably intended for general effect, rather than real illumination, and in this they serve the purpose fairly well.

The car is of the arched roof type construction which gives one an impression of plenty of room and good fresh air to breathe. In speaking of air, there are eight Garland ventilators in the ceiling of the dining room, these being of the new arched roof type design, and remove over 120,000 cubic feet of air per hour when going at a speed of 40 miles. Each ventilator is equipped with a damper so that the exhaust may be regulated at will. There is another ventilator of this same type in the pantry. The kitchen however, is ventilated by a simple inclined trap door opening in the roof, which may be tilted up at either end so that the motion of the train through the surrounding air will draw out all foul gases and smoke from over the stove. Two 12 in. fans are here suspended from the ceiling and direct a con-

tinual exhaust through this trap, so that it will be operative even though the car is standing still.

The car is of steel construction throughout except for the finish of the dining compartment which is in light mahogany, and the ceiling is finished in a light buff cream. All fixtures are finished in verde antique, and the fans, locker handles, ventilator gratings, etc., all harmonize with it.

The fans are of the latest General Electric railway car type with 12 in. blades, and are equipped with a removable base so that they can be readily removed. It is only necessary to loosen one screw in order to remove the fan in the winter time, and this leaves a rather artistic looking rosette which is set permanently into the car panel.

The motor is completely encased, and a small hand hole is provided over the brushes for inspection and repair. The fan is mounted in a fork so that it can be tilted at an angle if desired, and this fork is set into the fan base on a heavy bolt secured to the bottom by a lock nut.

In addition to the six 50 watt, and ten 15 watt lamps, there are twenty 15 watt lamps installed in the hall, kitchen, pantry and refrigerator.

A Gould axle lighting equipment with Simplex regulator type B generator and their new locker panel as shown in Fig. 2, and 25 cells of A. 8 H. Edison Storage Batteries of 300 ampere hour capacity, light the car. The lighting circuit panel with both lamp regulator and machine regulator panels is mounted in a special locker as shown in Fig. 2. This is a very convenient arrangement and simplifies both wiring and wiring troubles very materially. With this panel the only wiring below the car consists of three wires which run to the generator and two to the battery.

An illumination test was made using a small hand instrument, and although results are not absolute they are good enough for purposes of comparison. Readings were taken at the center of each table 34 in. above the floor, and three readings were taken at each setting. In no case did these readings at any one point vary more than 3. of a ft. candle. Lamp voltage was 29 volts throughout test. The results of this test are given in the accompanying diagram and illumination curves.

Fig. 2. New Gould Locker Panel.

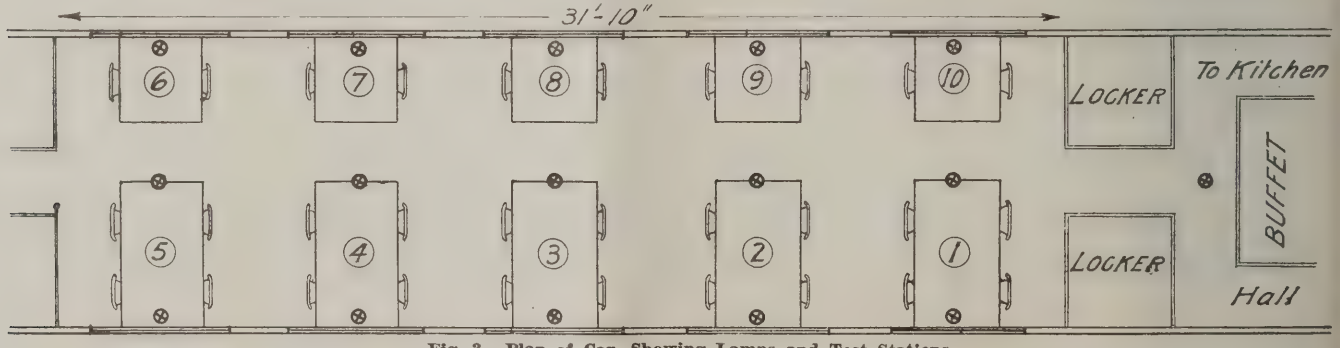


Fig. 3. Plan of Car, Showing Lamps and Test Stations.

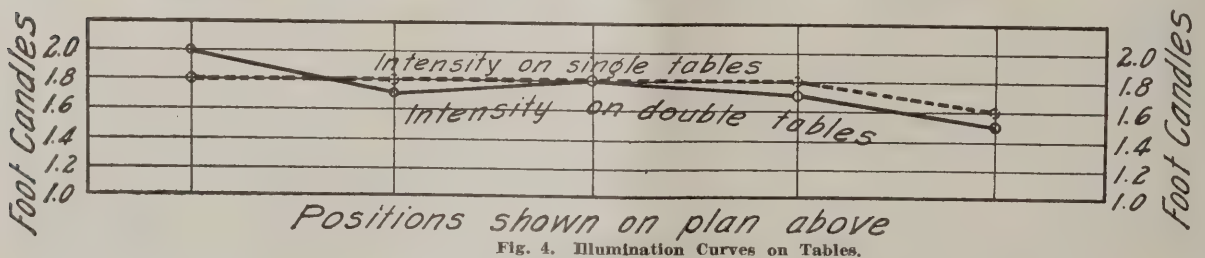


Fig. 4. Illumination Curves on Tables.

RESULTS OF TEST.

Position No.	Ft. Candles	Position No.	Ft. Candles
1	1.5	6	1.8
2	1.7	7	1.8
3	1.8	8	1.8
4	1.7	9	1.8
5	2.0	10	1.6

New Rock Island Battery House.

The Rock Island Lines have just completed a new battery house at their Chicago coach yards which is an example of the best and most approved practice in battery house construction. There are at the present time 326 axle equipments in service on this road, of which an average of 88 cars per day are handled in this yard.

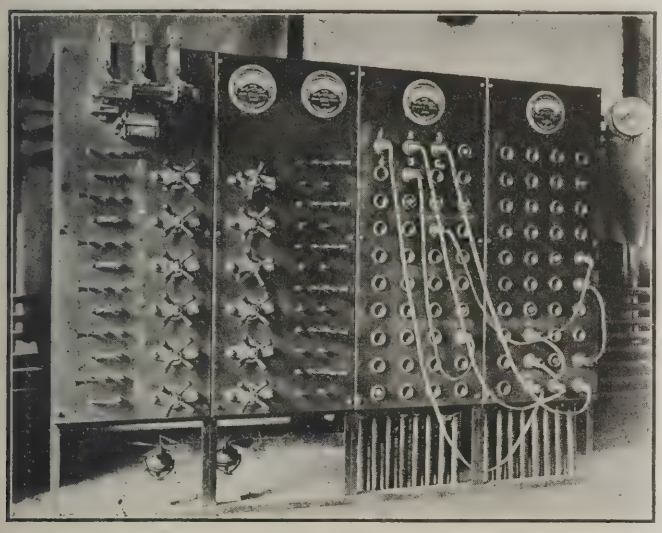


Fig. 1. Battery Charging Switchboard.

Power for battery charging is received from the new power station described in our March, 1912, issue. This comes as a 110-220 volt d. c. three wire circuit and passes first through an underload-overload I. T. E. circuit breaker as shown in the upper left hand corner of the in Fig. 1.

The wiring diagram of the board is clearly shown in Fig. 5, and it should be noted that the current flowing in any of the two circuits can be measured on a single ammeter. This is effected by the double throw switches in panels 1 and 2. Similarly the voltage of an individual car can be read by pluging in voltmeter terminal.

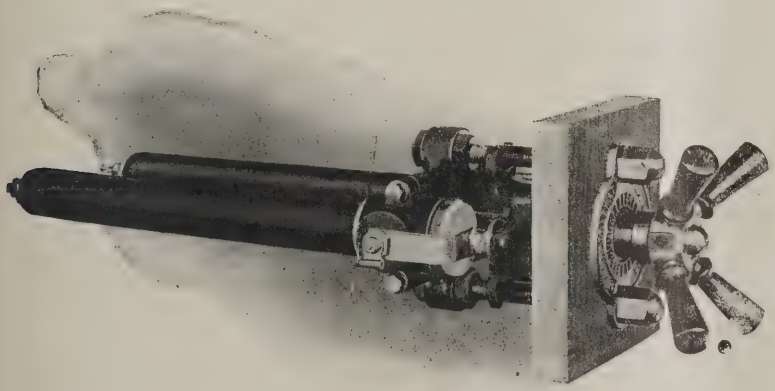


Fig. 2. Battery Charging Rheostat.

It is possible to charge a single car or two or three or four cars in series, no matter where they are located in the yard at either 110 or 220 volts as may be required This is also accomplished by plugging in loop conductors on the face of the board at the proper positions as shown in the wiring diagram, Fig. 5.

Method of detecting grounds on either side of the circuit is shown in the diagram, Fig. 4.

The connections are as follows:

For circuit voltage, plug 1 and leave 2 and 3 open.

For ground on negative, plug in circuit to be tested on 2, short on 3 and open 1.

For ground on positive, plug in circuit to be tested 3, short 2 and 1 open.

Allen Bradley rheostats are used for controlling the battery charging current and these, as shown in Fig. 7, are neatly mounted on the back of the board and take up very little space. A detail of these rheostats is shown more clearly in Figs. 2 and 3. They are of the well-known carbon pile type, the resistance of which is varied by changing the compression on the pile. All operators of axle equipments know that carbon discs will oxidize in time, and if the current passing through them is heavy so that there is considerable arcing and the carbons heat, disintegration may be very rapid.

To obviate this, the carbon piles in these rheostats are encased in air-tight steel tubes. These prevent the oxygen of the air from coming in contact with the heated carbon discs, so even though there be considerable arcing and heating of the discs, there will be practically no disintegration from this source.

The manufacturer, Allen Bradley Co., Milwaukee, claims these rheostats will operate satisfactory at 500 degrees F. They are designed to absorb 2000 watts, but as a matter of fact on a trial test lasting 5 hours, they consumed 2,800 watts without any apparent damage. This was an overload of 40 per cent. The temperature of the tubes on this test was 650.

Fig. 3 Carbon Discs Used in Rheostat.

The advantages of this resistance unit are very evident when one compares the back of this board with that of older types on which the resistance elements, consisting of iron grids, were, on account of their bulk, usually placed in a gallery above the board with a multitude of conductors leading down to contact points on the switchboard.

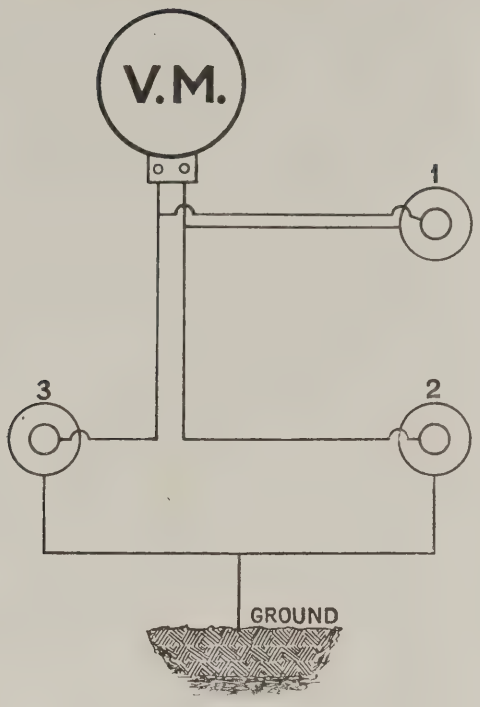


Fig. 4. Ground Test Connections.

that where circuits are not placed in series on the board, a short circuiting plug must be placed in one of the receptacles.

There are 32 yard charging circuits with an average of four boxes per charging circuit, making a total of 128

Fig. 6. Interior of Battery House.

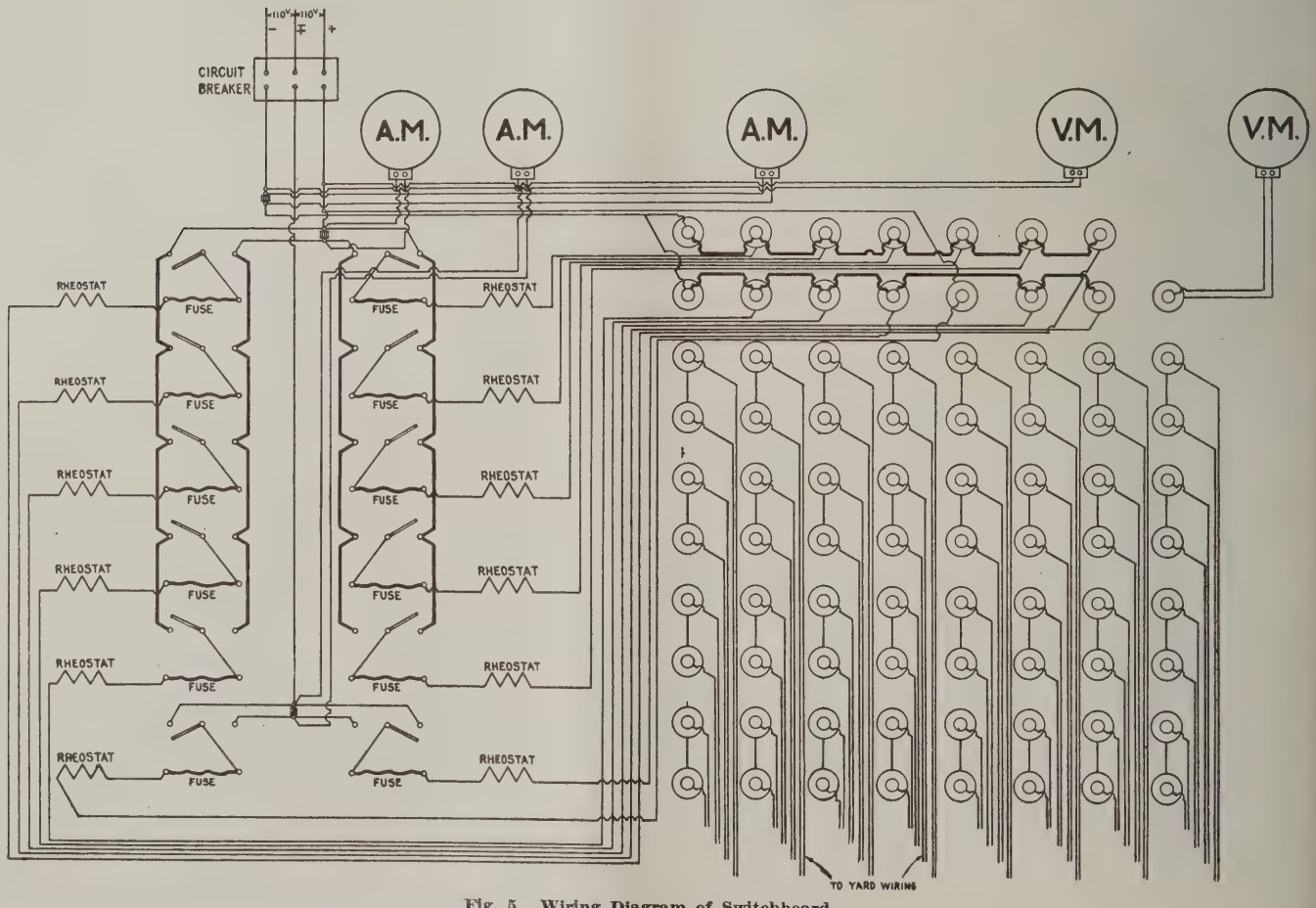


Fig. 5. Wiring Diagram of Switchboard.

There are two 10 in. fans on the floor directly below each vertical row of resistance elements and these fans direct a cooling blast of air upward, which will cool off the resistance units rapidly and permit of their working continually at a considerable overload, where necessary.

Small short circuiting plugs may be seen in certain receptacles on the switchboard. It will be noted from following out certain wiring connections of Fig. 5 charging boxes. This charging box is of the Pennsylvania type construction, having a heavy cast iron box of an inch thickness with cover and canopy holding two Anderson receptacles. A 2 inch conduit run is installed between boxes spaced at 90 ft. apart, and this is laid on top of the ground to get away from water troubles. The charging boxes are made waterproof with rubber gaskets, and they are of such solid construction that

when they are run into by one of the supply trucks, as occasionally happens, it is the truck that gets damaged instead of the charging box.

No. 4 rubber covered wire with double braid covering is used in all yard circuits. This is smaller than would be required if voltage regulation of the line were an important feature as in many other yard charging systems. In this case, however, the line drop does not affect the

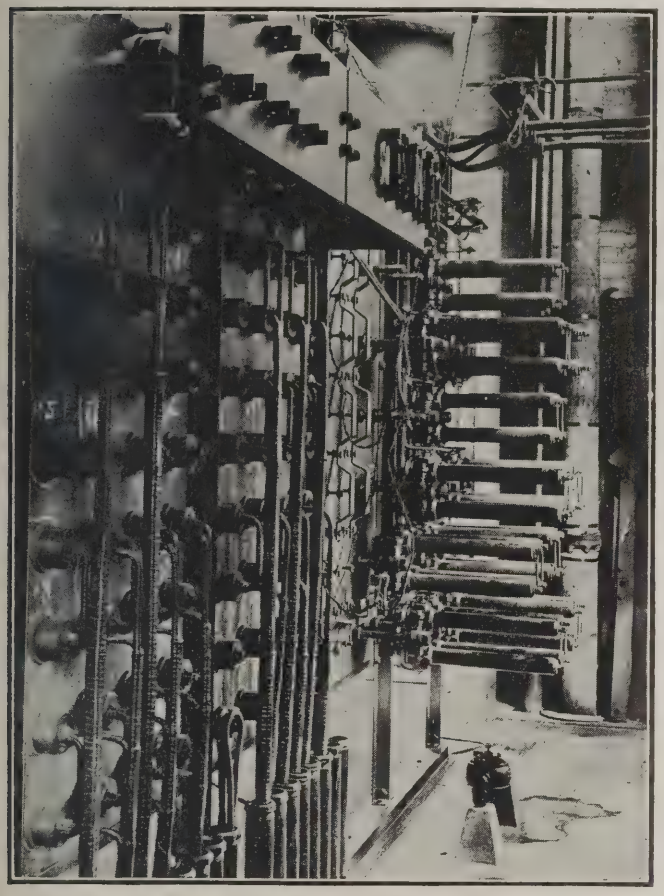


Fig. 7. Back of Switchboard, Showing Rheostats.

operation of the system. Short circuiting plugs are chained to each receptacle and these are removed only when charging plug is inserted into the receptacle.

The battery house is divided into two rooms, a switchboard room and generator shop, which is 34x37 ft., and the battery room proper which is 37x88 ft. Five low tables run the entire length of the room, the center one of which is equipped with seven charging plug receptacles as shown in Fig. 6. Later all 5 tables will be similarly equipped. These charging receptacles consist of a 2 in. Crouse-Hinds condulet with two special sleeves screwed into each end to accommodate the Anderson receptacles. These are mounted about 2 ft. above the table, and 3 ft. 6 above the floor and lead wires are carried in a 2 in. conduit run located beneath the bench. All receptacle boxes and conduit are thoroughly coated with a thick layer of petrolyte, the sealing combination used in lead lined tanks. Before applying the petrolyte, the conduit was heated with a blow torch thoroughly, and hot petrolyte then painted on. After cooling, the surface of the petrolyte was evened up and made smooth with a torch. This will probably protect the iron conduit and condulets from acid corrosion perfectly.

Vitrified bricks with asphaltum filling are used for battery floor. These are embeded in a 2 in. layer of sand with a 6 in. layer of concrete below.

At the further end of the room, as shown in Fig. 6, is installed the washing apparatus. Batteries to be washed are brought in from the elevator, which lowers them from the level of the track elevation; the elements are removed from the jars, and separators taken out.

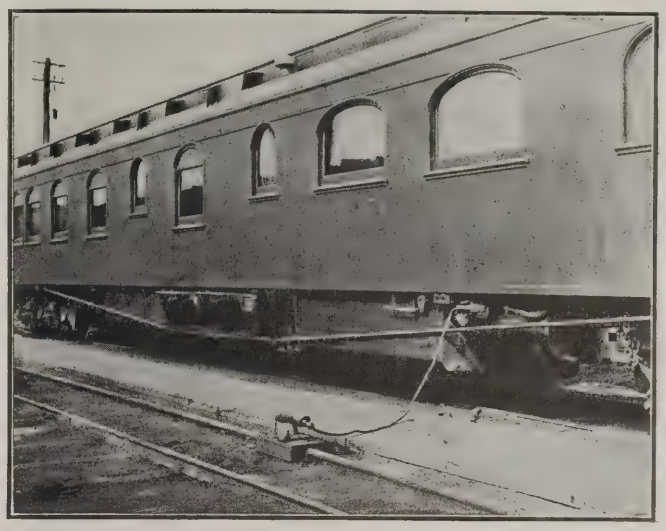


Fig. 8. A Battery on Charge.

If the plates are at all buckled, spacing blocks are inserted and they are then straightened out under an air press. This is an 8 in. cylinder, which, with air at 80 lbs. pressure, gives approximately 3,000 lbs. pressure on the plates. The old electrolyte is then carefully poured out of the jars so as not to disturb the sediment on the bottom of the tank which is then scraped into the barrel shown in the foreground of Fig. 9.

A novel air spray water fountain as shown in Fig. 9 is used for washing out the tanks. Small holes are drilled into the upper side of a ¾ in. pipe frame which is made into two small squares about 8 in. on a side so as to accommodate each tank of the double compartment.

The water is then turned on with air pressure of 100 lbs. through an injector like arrangement. (Fig 9.)

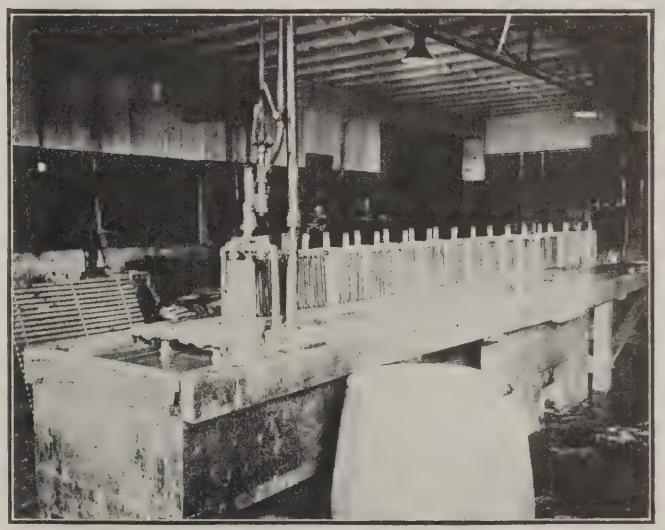


Fig. 9. Washing Table, with Fountain Over Tank in Foreground.

This, blowing out through the multitude of tiny holes, gives a washing spray of high velocity going in all directions, as each hole is bored from a slightly different angle. This washing spray is far more effective than a single stream of water.

This washes the tanks out clean and all sediment in the water is collected on passing through a series of

three sediment tanks, one tank overflowing into another, and that into a third. Most of sediment is caught in first tank which is easily cleaned.

After the battery tank or jar is washed out inside by the spray, the grease and acid corrosion which collect on the rollers and tanks are cleaned off by means of a spray of live steam at full boiler pressure. This is hot and wet and comes with terrific force so that it is a mighty effective cleaner. An air blast is then turned on which blows off any remaining drops of water and dirt from the surface of the tank, and as the tank is rather warm after its steam bath, the drying process is quickly over.

Two men with this equipment can clean four tanks in three minutes.

For making capacity tests on batteries after they have been cleaned and placed on benches, a truck is equipped with a small switchboard containing a lamp bank and instruments so that it can be wheeled right up to the battery on the bench and connections made without any permanent installation of testing circuits.

Acid for filling batteries is handled by means of a compressed air tank mounted on a truck together with the acid tank.

Industrial Illumination and the Average Performance of Lighting Systems.*

By C. E. Clewell.

Illumination in the past has been looked upon largely as an accessory. Modern illuminating engineering, however, is concerned with the adaptation of the available types of lamps to certain supply circuits, to various classes of service, and to given conditions of building construction.

A few years ago the older type of arc lamp and the carbon filament lamp, typifying a large and a small unit, covered the range of types of lamps available for illumination work in the industries. This limitation in candle-power has gone through an evolution by the introduction in more recent years of the enclosed arc, the open flame-carbon arc, the metallic flame arc and the long burning flame carbon arc lamp, as improvements on the original arc lamp; and the metallized filament, the tantalum and the tungsten lamp, as improvements on the original filament lamp. The Moore tube, the Nernst and the mercury vapor lamps are also available as new types.

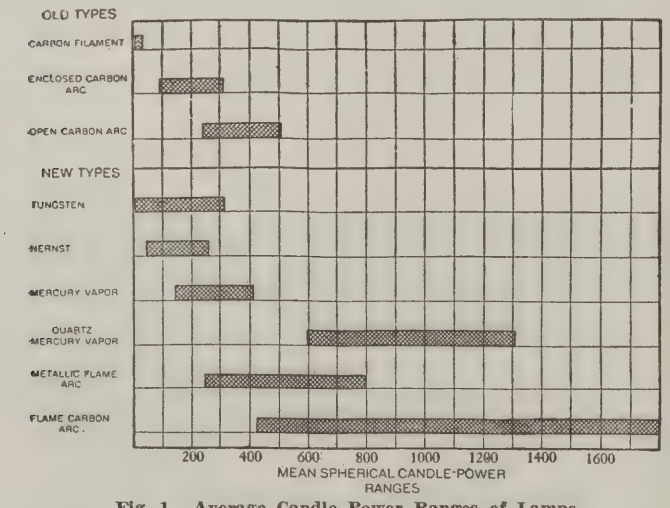


Fig. 1. Average Candle Power Ranges of Lamps.

The candle-power values of these various lamps are shown in Fig. 1 where, in an approximate manner, the average mean spherical candle-power values of all types, both old and new are indicated. Fig. 2 shows the over-all dimensions of the various lamps, from which it is apparent that the dimensions for given candle-power values have been modified by changes in design.

Re-directing the light where most useful should be included in development of high efficiency lamps as additional to the matter of total light flux per watt. The growing tendency to rate electric lamps according to the effective illumination produced on the work rather than in terms of the watts per mean spherical candle-power is evidence that this item will probably be included in the considerations of lamp efficiency more in the future than in the past.

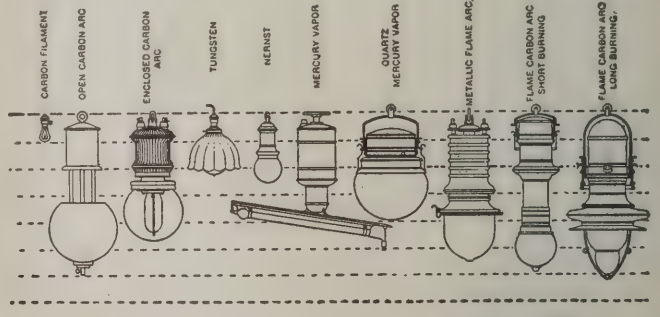


Fig. 2. Comparison of Dimensions of Various Lamps.

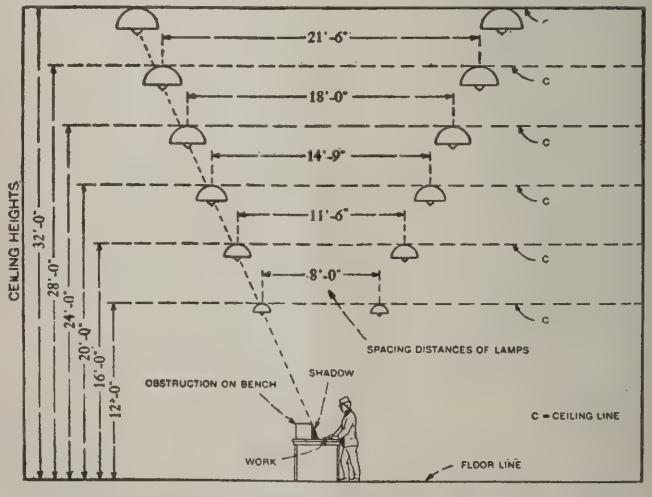


Fig. 3. Relation of Shadows to Mounting Height and Spacing.

Quantity of light is no longer the sole criterion of excellence, but its uniformity over the work, diffusion,

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adequate intensities on the sides of the work, absence of glare, color values and similar items are now given an importance almost if not equal to mere satisfaction in the matter of vertically downward intensities.

Shop work generally speaking may be grouped into work on a horizontal plane, as bench work of some

TEST RESULTS ON TUNGSTEN SYSTEMS WITH GLASS REFLECTORS.

Efficiency values* Conditions of test	Low office	Fairly high factory office	Low factory space	Medium high factory space	Fairly high factory space
Ceiling	Light	Light	Dark	Light	None
Wall	Light	Light	None	Light	Dark
Lamps	60-W Cl	60-W. Cl.	100-W Cl	100-W Cl	100-W Cl
Reflectors	I-60 SF	I-60 Cl.	I-100 Cl.	I-100 Cl.	F-100 Cl.
Class of work	Desk	Desk	Machines	Bench	Bench
Time between washings	14 weeks	17 weeks	9 weeks	11 weeks	13 weeks
Results		Efficiency	in per cent		
Soiled lamps Soiled reflectors	19 7	24 2	22 4	25	20.1
Clean lamps Soiled reflectors	20 7	24 9	22 5	27	23.6
Clean lamps Clean reflectors	34 1	29 3	31 2	35.3	33.6
New lamps Clean reflectors	34 1	31 2	31 9	36.1	39 1

*All efficiency values corrected for normal lamp voltage.

Fig. 4.

kinds, which, in the main, requires only downward illumination; and other work as that included under machine tool operations, foundry moulds, rolling mills, assembly, and the like, where, in addition to vertically downward light, side components effective on vertical planes, as well as shadow elimination, play an important part in the excellence of results.

The height of ceiling, roof or trusses limits in a very large measure the size and type of lamp to be employed. Experiment and usage demonstrate the disadvantage of using very large lamps for low ceilings, while lack of economy prohibits the use of small lamps for high areas. In former years arc lamps were used for low factory bays, while in some extremes no appreciable general illumination was possible due to the absence of sufficient clearance between cranes and ceiling for

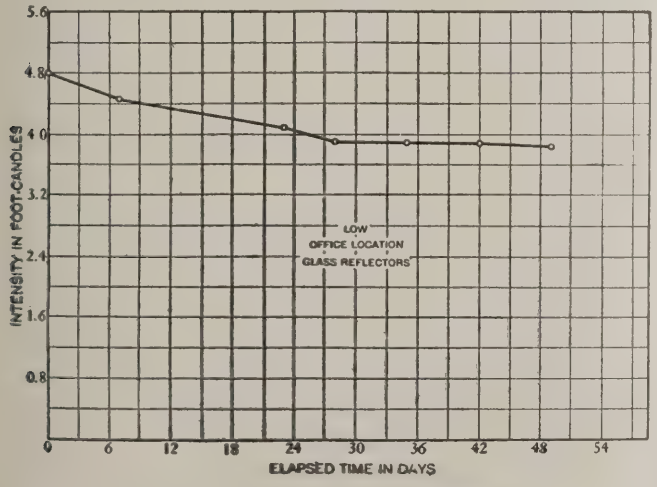


Fig. 5. The Effect of Dirt Accumulation

an arc lamp. In like manner very high bays have been inadequately lighted due to the lack of lamps possessing sufficient candle-power and suitable distribution characteristics. Today, however, lamps of enormously greater candle-power and more suitable distribution are available for the higher areas, while lamps with corresponding advantages are available for low areas.

Open spaces simplify the problem by permitting the use of lamps spaced comparatively far apart, while the interference of belting calls for a type and arrangement of lamps which will provide diffusion, so as to reduce the shadows ordinarily produced by belts. In an atmosphere filled with dust and dirt a penetrating light should be employed, and in spaces of the latter class the maintenance is apt to be greatly increased with the rapid accumulation of dirt on the lamps and reflectors.

Illuminating Factors.

The spacing distance of lamps is a first consideration. Experiments have shown, for example, that in certain office locations with moderate ceiling heights, a spacing distance not exceeding 7 ft. 6 in. is most advantageous. This results in a uniform illumination on the desks if the proper reflectors are used, and the light from a sufficient number of sources thus secured insures a diffusion of the resulting illumination. The directional features of the light are furthermore far superior to those cases where larger spacing distances are employed.

The spacing also governs the size of lamp to be used. As an illustration, whether one 250-watt or four 60-watt tungsten lamps are to be installed for a given area will be influenced largely by the desired directional features of the light.

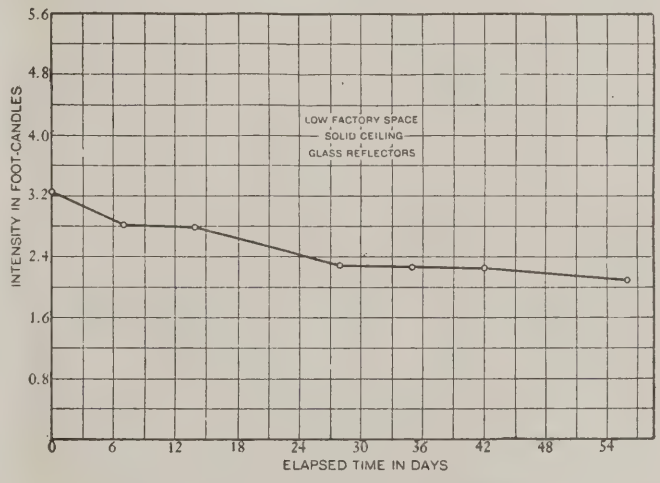


Fig. 6. The Effect of Dirt Accumulation.

The mounting height should be determined on a basis of the avoidance of glare and of the ease in getting at the lamps for maintenance. The lamps should be mounted high enough to be out of the line of vision, and where the ceilings are too low to admit this, lamps of small size should be selected to reduce the quantity of light flux which enters the eye or is effective thereon when looking into any lamp. Fig. 3 shows the effect of height on the directional qualities of the resulting illumination on the working surface. The illustration shows graphically the need of closer spacing to maintain a given minimum shadow effect for the ceilings.

Heretofore the measure of illumination efficiency, if it may be so called, has been changed in turn from watts per square foot required to furnish presumably satisfactory light; to lumens per watt (or foot-candles per watt per square foot); and finally to efficiency or the utilization of the total light flux of the lamps. The latter is a measure of the total losses from all causes, such as absorption by globes or reflectors, by dark ceilings and walls, as well as by dust, dirt, belting, or other obstructions, and therefore adapts itself in

an excellent manner to practical usage. One other feature should be noted in connection with the efficiency, namely, the importance of considering average performance, in distinction to results obtained when lamps and reflecting devices are new and clean.

The need for data on the *average performance* of illumination systems has been felt for some time. With the view of meeting this need, and also for the purpose of establishing some certainty regarding the various factors involved, extensive tests have been conducted during the past year, and the results of the same are now herewith presented for the first time in the hope that they may furnish useful information on this important phase of illumination system, and also serve to further additional work, thus begun in this particular direction.

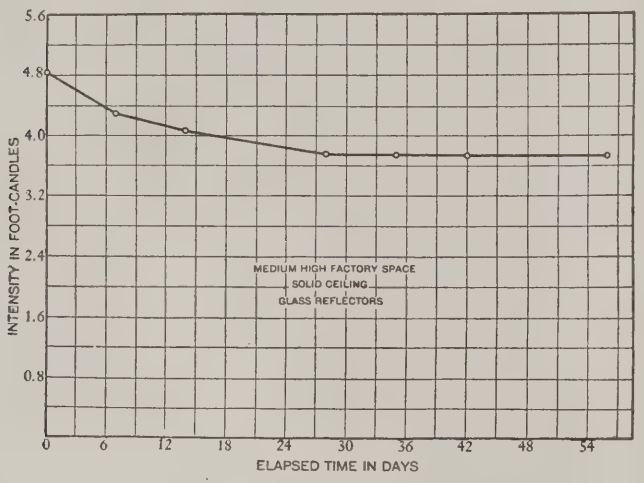


Fig. 7. The Effect of Dirt Accumulation.

These tests covering 17 weeks work were made on the vertically downward (or so-called horizontal) intensities of the illumination produced by a fairly large number of lamps in each location, thus securing a more general idea of the changing conditions than would likely result from individual tests on single lamps or reflectors. By these tests it has been sought to establish the actual efficiency of the various illumination systems considered, as compared to the theoretical efficiency which might be supposed to exist from calculation based on candle-power distribution curves. Four conditions were chosen as follows: (1) new lamps and reflectors; (2) clean lamps which have been in service for several months, and clean reflectors; (3) clean lamps several months old and soiled reflectors, ready to be washed in the routine of the plant; and (4) soiled lamps and soiled reflectors ready to be cleaned.

Fig. 4 shows the results of these tests and the attending surrounding circumstances. The value of these constants can hardly be overestimated when considered in the light of their usefulness in the calculation of factory lighting systems, which can thus be based on absolute experience. The foregoing notes apply to the performance of a system as installed and in regular service.

Depreciation Items. In the calculation of illumination systems additional factors must be taken into account, namely, (1) the effect due to the operation of the lamps at a voltage other than their rating, frequently the case in tungsten system; (2) the depreciation of candle-power due to the aging of the lamps; (3) the depreciation due to surroundings which are liable to become dark; and (4) the effect of dust and dirt accumulations.

The losses due to *voltage* conditions can readily be calculated from the curves showing the variation of candle-power with voltage; the effect of *age* of the lamps, although somewhat more uncertain, can be determined with a fair degree of accuracy from the life

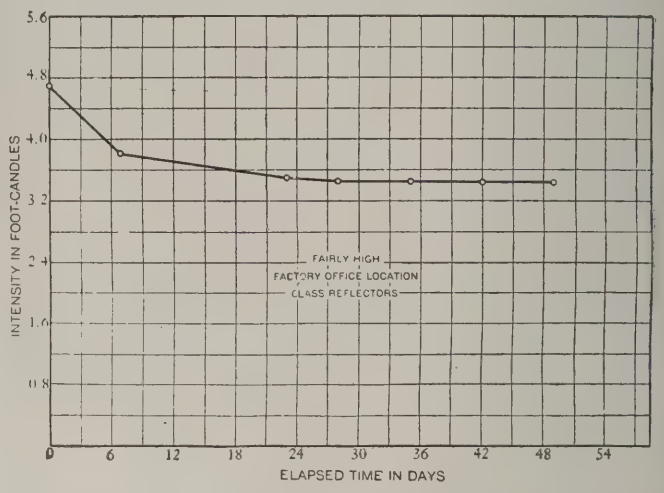


Fig. 8. The Effect of Dirt Accumulation.

curves of the lamps as made by the lamp manufacturing companies; tests have been conducted as previously referred to, in the determination of the effect of *surroundings* on the illumination results. The following material has resulted from extended tests on a variety of lighting systems to determine the dust and dirt characteristic depreciation curves with elapsed time of service.

Figs. 5, 6, 7, 8 and 9 indicate the characteristic curves of illumination intensities over a number of weeks as the result of the tests, and from these curves the very interesting and instructive conclusions may be roughly drawn, that under average factory conditions the deterioration of glass reflectors due to dust and dirt follows a fairly definite rate of candle-power reduction, in as far as conclusions can be deduced from the number of cases on which these tests were conducted. This reduction as shown in the curves is due alone to dirt accumulations on the reflectors, since

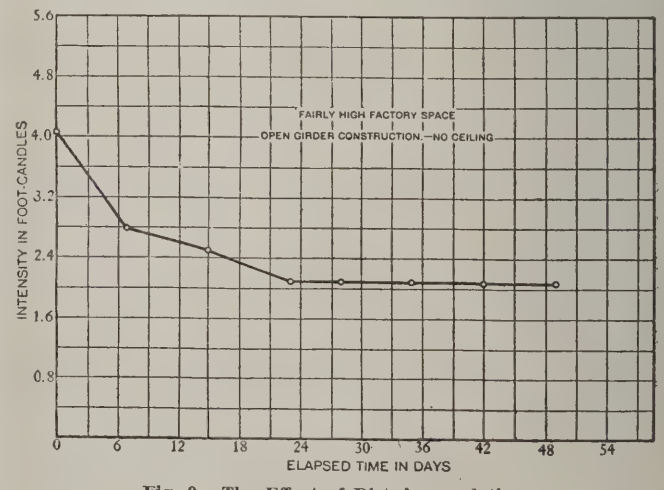


Fig. 9. The Effect of Dirt Accumulation.

the new lamps were inserted before each test and all observations were corrected to correspond to normal lamp voltage.

The curve sheet shown in Fig. 10 has been derived from the deterioration curves. This curve sheet shows, for example, that based on the average cleaning cost of three cents per reflector, with energy at two cents per kilowatt-hour, the integrated cost of light lost at the end of sixteen days in one of the cases, is equal

to the cost of cleaning. This point (namely sixteen days) would then naturally determine the economical interval for cleaning reflectors in this particular location, provided always that the reduction in intensity at the end of this interval is not below that which is necessary for satisfactory vision. It is of interest to note that apparently the effect of dust and dirt takes place far more rapidly in the first week or ten days than during the succeeding weeks.

Our useful information may be deduced from these curves as follows; if, for example, the loss of light at the end of sixteen days equals 25 per cent, which means, for an initial intensity of four-foot candles, there remain, at the end of sixteen days, only three-foot candles, the average intensity throughout the sixteen day interval may be approximated at three and one-half foot-candles, provided the reflectors are cleaned once every sixteen days.

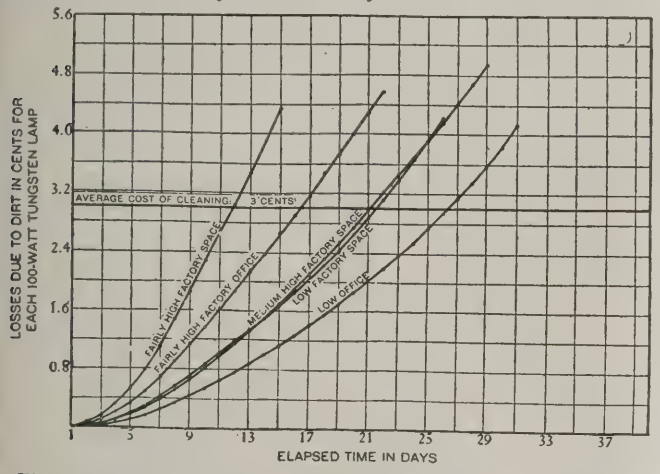


Fig. 10. Summary of Curves, Fig. 5 to 9, Showing Effect of Dirt.

If an additional sixteen days without cleaning means a still further reduction from three to two foot-candles, the average intensity of the illumination throughout the thirty-two days interval may be approximated at three foot candles. Hence the cleaning of the reflectors at intervals of sixteen instead of thirty-two days, should insure an average intensity of say three and one-half instead of three foot-candles, or in other words to maintain an average of three and one-half foot-candles would require approximately twenty per cent more lamps in the installation for a thirty-two days than for a sixteen days cleaning interval.

Necessity for Systematic Maintenance. From the foregoing statements the necessity for careful and systematic maintenance will at once be apparent. In one large system of 10,000 tungsten lamps, the losses of light per day due to dust and dirt interpreted into money values, that is to say, evaluating the energy in watts represented by light wasted through absorption by the dirt, to its kilowatt hour cost, amounts approximately to $20 per day, or $7,500 per annum. If the systems are allowed to go uncleaned beyond the economical point, these losses become aggravated.

In one large shop where extensive installations of high efficiency lamps have been under way for nearly three years, a summary shows an increase of nearly 30 per cent in actual candle-power for a 5 per cent increase in total operating and maintenance costs. This increase of 30 per cent in candle-power in no way, however, indicates the enormous improvements in the matter of excellence in distribution and refinements of results; it merely shows what great advances have been made in the possibilities of industrial illumination by the newer types of lamps.

SHOP SECTION

EDITED BY

GEO. W. CRAVENS

Motor Talk No. 1

PRINCIPLES OF THE ELECTRIC MOTOR.

This series of talks is designed to bring out in a general way the most important underlying principles of operation of electrical motors, especially such features as bear most closely upon their adaptability to railway electrical applications. This will include motors for driving cars, turntables, cranes, etc., but will deal mostly with motors for machine tools and similar applications.

By referring to the *"A. B. C. Car Lighting Series"* the reader will find the Principles of Electricity and Magnetism very clearly outlined in the first two articles of that series. There are certain features of those talks we will repeat for emphasis as they are important in studying the differences between motors and dynamos. In general the action of the two forms of dynamo-electric machines is very similar and a knowledge of either one makes an understanding of the other easier.

We know that the space surrounding the tips of a magnet is under a sort of "strain" and that this condition shows certain features which we are in the habit of referring to as "lines of force" passing from one of the "poles" of the magnet to the other. Also, that it makes no difference whether we consider a "permanent" magnet (such as the "horse-shoe" type so familiar to every boy) or to an "electrc-magnet" created by winding wire about

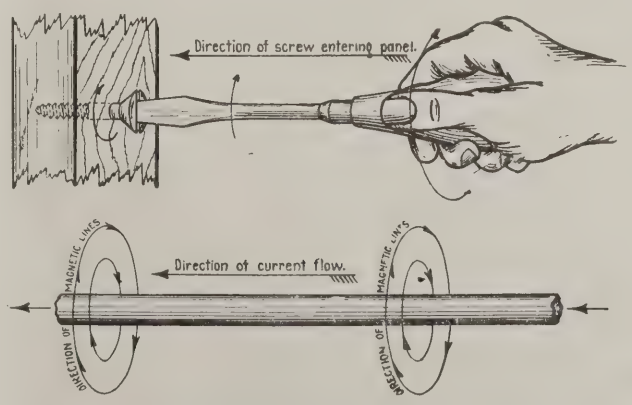


Fig. 1. The Rule of the Screw Driver

a piece of iron or steel and passing a current through the wire. We also know that if we pass an electric current through a piece of copper wire or other conductor that

a magnetic field its set up in the space surrounding the conductor, this being made clear by the "Rule of the Screw-Driver," Fig. 1. If the current flows through the wire in the direction of travel of the screw, the magnetic lines about the wire will circulate in the direction of rotation of the screw-driver. This is equally true for both directions of flow (tightening or loosening the screw.)

Motors, like generators, consist of a set of electro-magnets arranged about a space for the armature to rotate in, this space being the path for the "lines of force" or "flux" between the poles of the magnets. Upon or near the surface of the armature are placed the wires or bars for carrying the current which passes through the armature, and it is the action of the magnetic field set up by this current that we will study first. The body or "core" of the armature is made of thin plates of soft steel in order to provide a better path for the magnetic lines, and the reaction between the lines of force passing through the armature core from the pole pieces and the lines of force set up about the conductors of the armature is a very important peculiarity of the electric motor.

When a conductor is moved through a magnetic field, lines of magnetic force form about it and a current flows through it, the direction of flow depending upon the direction of travel with relation to the path of the lines of force. This was brought out very clearly in the illustrations accompanying the description of generators.

The action in a motor is just the reverse. When a current is caused to flow through a conductor lying in a magnetic field, the induced magnetic field about the conductor causes a reaction between the two magnetic fields which forces the conductor to pass out of the original field. This will be made clear by reference to the accompanying Fig. 2.

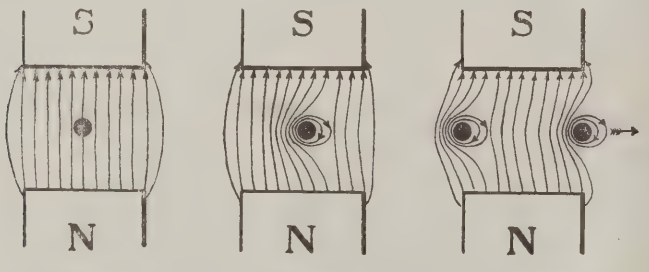


Fig. 2. Showing Why a Motor Revolves.

It will be noted that with the current in the wire flowing in a direction away from the observer that the lines of force (really invisible) circulate in what may be called a "right hand spiral." With the conductor dead there is no motion, but as soon as the conductor is energized sufficiently to set up a magnetic field about it (strong enough to overcome friction or inertia) there is motion. In the illustration given herewith the motion will be to the right because the lines of force travel up and the current is travelling away from you. *It is as if the lines about the wire were a car wheel and the North pole of the magnet were the track.* If the current is reversed the travel will be reversed, also, in same field.

In a motor, the magnetic field is set up by the field magnets which are excited by the current passing through their windings from the line. Current is also led into the armature windings through the brushes and commutator, and it is the reaction between the magnetic field and the effect of the current in the conductors on the armature (as explained) that causes the armature to rotate. The armature windings are connected to the commutator in such a way that the current flows only through those coils which are in the magnetic field, the direction of rotation depending upon the direction of flow.

We found, in the case of the generator, that when a conductor is moved through a magnetic field there is a current caused to flow in it, due to the generation of an electro-motive force in the conductor. In a motor we have a similar condition; an armature revolving in a magnetic field and conductors cutting across lines of force. This is due to the action between the field and armature, instead of being driven by an engine, but does not prevent the generation of an electro-motive force in the armature conductors. But, since this E. M. F. is the result of moving the conductor through the magnetic field (as with a generator) the flow of current will be in the opposite direction to that passing through the armature conductors from the line. Hence, it is called the COUNTER E. M. F.

The E. M. F. of the generator supplying current to the motor must always be greater than the Counter E. M. F of the motor or no current would flow into the motor and it would not run. When a motor is first started the counter E. M. F. is zero, because the conductors are not cutting magnetic lines of force, so the rush of current is very great. But as soon as the motor speeds up the counter E. M. F. increases until it nearly equals the impressed E. M. F., the difference being due to the E. M. F. required to overcome the resistance of the armature windings. If the field windings are also in series with the armature, as with a railway or hoist motor, the resistance of these windings further increases the voltage drop.

When the windings of a motor are energized and the armature held so it cannot turn there is a strong twisting or turning effect exerted, due to the tendency of the armature coils to jump out of the magnetic field. But, no power is developed because they are unable to move and all of the electro-motive force supplied by the line wires is used in forcing the current through the armature against its resistance. This resistance is comparatively small, due to the size of the wire making up the winding, so the voltage can send quite a lot of current through them.

The watts so supplied are used up in heating the armature conductors and field windings, but, if the motor armature is allowed to turn there will be a counter E. M. F. generated by the motion of the conductors through the magnetic field and this will choke back most of the current and reduce the amount taken from the line. The amount of energy then used will be only that due to the ability of the reduced electro-motive force to send current against the resistance of the windings.

This turning or twisting effort is called the "torque" of the motor and is equal to the torque exerted at the pulley plus the torque required to overcome friction in the motor. As soon as the armature is free to turn the motor is in a position to deliver power, and the current which flows will be that required to enable the motor to carry its load and to make up for its own losses. The torque of a motor depends upon the field strength, the number of armature conductors and the amount of current in the armature conductors.

There are certain losses in a motor, the same as in a dynamo, which cannot be avoided. These are the losses due to mechanical friction, the resistance of the field windings, the watts lost in the armature due to heating (C^2R) and the loss in the iron cores due to hysteresis and eddy currents. The latter are the effect of the magnetism and need not be discussed in detail just now. From these losses taken all together we determine the efficiency of a motor.

The "commercial efficiency" of a motor is equal to the ratio of the useful power delivered at its pulley to the total power taken from the line. The "electrical efficiency" of a motor is the ratio between the power consumed in the armature and the total power taken from the line. In this case the small losses in the fields are neglected. In a motor, the electrical power used in the armature is determined by multiplying the current flowing in it by the counter-electro motive force generated by it. This is similar to a dynamo, wherein the electrical energy generated in the armature of a dynamo is the product of the E. M. F. generated and the current flowing through the windings.

The higher the counter E. M. F. as compared with the E. M. F. of the line the higher will be the efficiency of the motor. If the resistance of the motor armature is very high the counter E. M. F. will be quite a bit lower than the line E. M. F. and reduce the efficiency of the motor. This is because a larger part of the line E. M. F. is necessary to overcome the resistance of the armature windings instead of being available for overcoming the counter E. M. F. generated in the windings, and enabling the motor to do useful work. Thus we see that a low resistance armature is just as important in a motor as in a dynamo.

Classes of Motors.

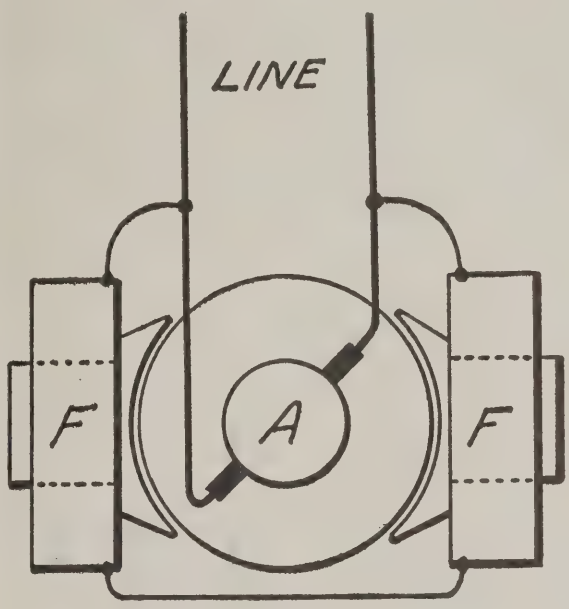
Direct-current or continuous-current motors are usually classed according to the method of exciting the field windings, similar to dynamos. Motors are usually of one of three classes, Shunt-wound, Series-wound or Compound-wound, the other kinds being so rare as to not warrant space here. Practically all motors are operated from constant-potential circuits, the current taken by the motor varying with the load. So we will consider each of the three general classes in detail from this standpoint, as we go along, but will take up a few general points first in order to bring out the principal differences between the three classes.

A motor consists of two main or principal parts, the armature and the field or frame. The armature winding lies on or near the surface thereof in order that its pull may be exerted at as long a radius as possible and in order to bring it to the most dense part of the magnetic field. The field is arranged in such a way about the armature as to form an economical magnetic circuit and to form a dense field for the armature windings to rotate in. This magnetic field is formed by the windings on the pole pieces composing it. On one end of the armature is a device called a commutator for connecting the various coils of the armature winding in the circuit at the desired times, as described in the section covering Dynamos in the Car Lighting Series.

It is evident that, before a motor can run, both the field and armature windings must be energized, and upon the relation of these two portions in the circuit depends the class of the motor. If the internal connections are such that the current divides, part passing through the armature and part through the fields, it is a shunt motor. If the connections are such that all the current passes through both the armature and field windings, one after the other, it is a series motor. If the connections and field windings are such that a part of the current passes through a part of the field windings and the balance of it through the rest of the field winding and then through the armature winding (in series) it is a compound wound motor. The accompanying diagrams will show the relative connections of the three classes.

Shunt-wound motors are used more than any other kind for operating machinery because of the speed regulating qualities. Since the line potential is kept constant for this class of service the field strength will be constant because the field windings are connected directly across the motor terminals (the line, also) and the resistance of the field windings is constant. The exceptions to this will be stated later under the heading of "Speed Regulation."

The field coils will normally supply the same magnetizing force, regardless of the amount of current taken from the mains by the armature, because they are not in series. If there were no de-magnetizing action of the armature the strength of the field would be practically constant. When a shunt motor is running free the only current taken from the line is that required to overcome internal losses, such as friction, etc. and the armature



SHUNT MOTOR.

Fig. 3.

speed will be such that the counter E. M. F. will allow only the amount of current to flow which is needed to overcome the internal losses. In a good motor this current will be very small, so the counter E. M. F. is nearly equal to the line E. M. F. when running light.

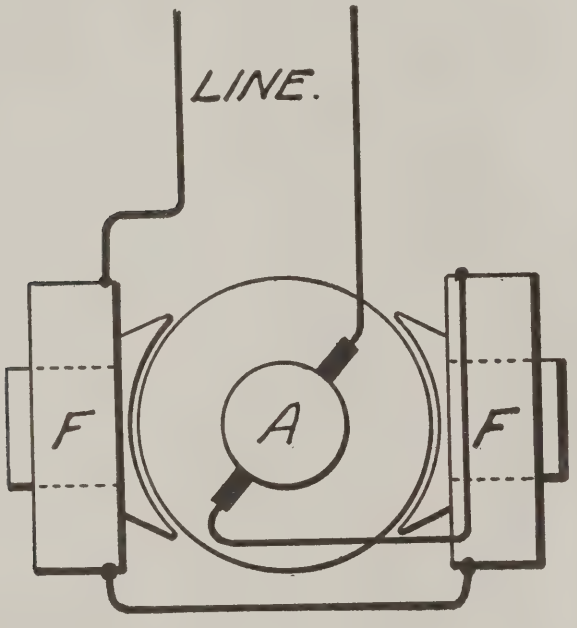
If a load is put upon a shunt motor it must take enough current to produce the torque necessary to carry the load. In order to allow this current to flow the counter E. M. F. must be reduced, so the speed must drop a little because the field strength is practically constant. But, if the armature resistance is low and the motor otherwise well designed the speed reduction from no load up to full load will be very small. Even if the load should be accidentally thrown off entirely there will be no tendency for the motor to run away because shunt motors automatically adjust themselves to changes in loads.

Series-wound motors are used almost exclusively for railway motors, hoist and crane motors, turntable and other motors which are in service requiring variable speeds and high starting torque. They also operate almost entirely on constant voltage systems. Owing to the method of connecting the windings in a series motor there is a great tendency for them to race or run away when not loaded. Of course, a series motor, like any other one, will take just enough current from the line to overcome the losses due to friction, core losses, etc., when running light. But, as the armature speed

increases the counter E. M. F. also increases, so the amount of current which can flow decreases. Since the field is in series with the armature, the field strength decreases as the current decreases and the armature must run still faster to generate the required counter E. M. F. This is about equal to the line E. M. F. at no load.

If the motor is well designed the no-load current will be very small and the speed required to generate the necessary counter E. M. F. will be excessively high, enough perhaps to cause the armature to fly apart. This why it is not safe to start series motors without loads or to throw the load off when running, without opening the circuit. When used with hoists they are under the control of the operator, as in railway work, so are satisfactory. The starting torque of a series motor is high because the current must flow through the field as well as the armature, thus giving a good field for the armature currents to react upon.

The torque of a series motor depends directly upon the amount of current flowing through it, and when the motor is loaded the counter E. M. F. decreases slightly and allows more current to flow. This current in turn



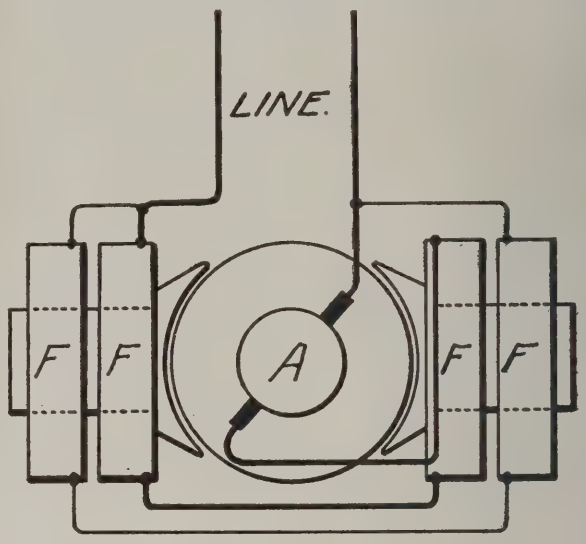
SERIES MOTOR.

Fig. 4.

strengthens the field and a corresponding increase of torque results. This is why series motors are used for railway work, a strong torque being produced by simply allowing a heavy current to flow while starting.

The field strength of a series motor increases as the load is applied, so the speed will decrease to correspond, that is why they are not good for ordinary power and machine motors. They are more substantial than other kinds and cheaper to build, and much less apt to give trouble.

Compound-wound motors are used for some classes of machinery requiring the characteristics of both shunt and series wound motors, such as planers, slotters, etc. With these motors the shunt field winding is to keep the speed practically constant regardless of load (providing the potential is constant) and the series winding is to give high starting and running torque. In view of the explanations given for the shunt and series motors, the action of a compound motor should be readily understood. The "Differentially-wound" motors, once so common, are now superseded almost entirely by shunt



COMPOUND MOTOR.

Fig. 5.

motors. They had two windings, similar to the compound motors, but one of them was connected so as to oppose the other and give constant speed regardless of load, on constant potential.

HOW IT HAPPENED.

Editor Railway. Electrical Engineer!

A few days ago I had to move a shunt-wound direct current motor from one part of our shop to another and, after getting it set in place and connected up, an accident happened which made me think I saw snakes or some other thing.

The motor was running all right and we were going away when a large timber fell on the motor in such a way as to pull one of the shunt field-leads loose, but the motor kept right on running. We examined it very carefully and could see no reason why it should not stop, because I always thought a motor would not run unless the fields were alive.

The only thing I noticed was that the motor would stop if we put very much load on it, and when the brush holder was moved to the regular position. When the timber struck the motor it moved the brush holder way over to one side, but did no damage, for the motor kept running. We fixed the shunt lead again and everything is all right now, but will you please tell me what made the motor run in that condition? G. H.

Answer.—Your motor continued to run because of the reaction of the armature upon the field, and was made possible by the shifting of the brushes. Armature reaction is present in all kinds of dynamo-electric machines, but its affect in motors is different from that in generators. The effect of the armature current is to cross-magnetize the field, that is, shift it to one side in the air gap, causing greater magnetic density at the leading corner of the pole-pieces. The effect of cross-magnetization is to shift the field backwards, instead of forwards as in a dynamo, so the brushes must be shifted backwards also to prevent sparking. In your case the motor was probably made with a comparatively weak field and a large amount of wire on the armature, thus increasing

the effect of armature reaction. With the brushes set either ahead or back of the neutral position a motor will run with the armature alive and the field dead, due to the field set up by the armature reaction for the armature current to react upon. The neutral position in such a motor would be back of the center of the space between the poles instead of just half way between them.

G. W. C.

Lesson No. 8.

Axle Generator Regulators

In this lesson we are going to try and get a line on some of the general principles of axle lighting machine regulators, and this will be followed later with a detailed description of each of the various regulators now in service.

Did you ever stop to think that an axle equipment is really a complete little central station that runs itself? In fact, does so under the worst possible conditions, those of greatly varying and intermittent speed, and being placed right down on a car truck where the machine is banged and bounced around at a great rate, and where flying ballast, sand and cinders, water, snow and ice, all operate at their maximum efficiency to put the equipment out of business.

What would an engineer in charge of a power station think if his engine stopped every 15 minutes, and when it did run, ran at anything from 10 to a 1,000 revolutions per minute. I think most of them would be fit subjects for the insane asylum in about two weeks, don't you. Yet that is the way every axle equipment must operate, and when you think of it in that light it is not surprising that we have some trouble with their operation.

There are several principles upon which an axle generator can be controlled so that the wide variations in train speed will be taken care of.

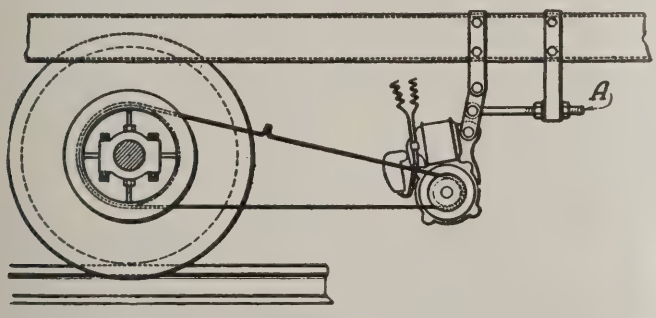


Fig. 34. Belt Slip Type Regulation.

1. Probably the simplest one is that which depends upon belt slipping at high speed, so that the generator runs practically constant after it gets up to a certain speed. There are thousands of equipments in Europe, India and Australia, and in fact, many in Canada which operate on this principle. This is known as the Stone system, and the operation is illustrated pretty well by the accompanying sketch, Fig. 34.

The generator is hung from a single pivot as shown, and is pulled out of virtical position by the belt tension. There is an adjustable link "A" with bolt and nut so that the output of the generator can be adjusted. This type of axle equipment was tried out in the early days by the Gould Company, but has never been much used in this country, probably because of the fact that our cars are much larger, the lamp load heavier, and the requirements of lamp regulation much higher than they are in Europe.

Armature Reactions.

2. Then another might depend upon armature reactions when the magnetic field is distorted at high speeds (see page 247 of our March issue).

The Rosenberg generator, rather extensively used in Germany, operates on this principle. At higher speeds, the magnetic field of the generator is automatically distorted to such an extent that the effective voltage delivered at the terminals remains practically a constant.

Differential Series Field.

3. A differential series winding might be placed on the generator field which would automatically buck the voltage down as the current went up. Both of these last two, however, require a larger and heavier generator, and they would probably both tend to heat the generator excessively and even at best, would be not much more than a make-shift.

Varying Field Current.

4. The type which is most generally used in this country, is that regulation which controls the generator current or voltage by reducing the generator field current as the train speed goes up and vice versa. There are a great many different devices which are used to produce this same effect, but they may be divided into three classes:

1. Generator current control.
2. Battery current control.
3. Combination generator current and voltage control.

Generator Current Control.

1. Most of the equipments now in service are included in the first class. The generator current passes through a solenoid which operates a plunger that cuts in or out the generator field resistance for rise or fall in train speed. There are modifications of this general principle in which there is differential winding on the controlling solenoid through which lamp current passes. The magnetism from this winding opposes the magnetism of the main winding, with the result that as the lamps are turned on, the generator current will be increased to take care of all, or part of lamp load as desired.

Battery Current Control.

2. An example of the battery current regulator is the old Bliss bucker, in which the battery current only passed through the controlling series coil of the bucker. In this system, generator current has nothing whatever to do with the regulation, and lamp load is taken care of simply by an increase in generator output just as it is on any stationary constant potential system.

Current and Voltage Control.

3. The third class, that of combination generator current and voltage control, includes most of the latest types of equipment. The new U. S., Safety, and the Gould Simplex regulators. These equipments have two separate solenoids, one with a heavy series winding

which carries all the generator current; the other, a fine winding which is placed directly across the generator terminals and the magnetism of this coil increases with an increase in generator voltage. All of these equipments operate as simple constant current devices until the battery has been charged up to a certain point, usually 42 volts on a 32 volt system; when this voltage is reached, however, the voltage coil becomes operative, and the battery charging current is gradually tapered off to a low value. In the U. S. equipment it is immediately cut off by reducing the generator voltage to 36 volts, so that the battery merely floats, the generator, simply carrying the lamp load.

ADJUSTMENT OF REGULATORS.

It should be noted that with all current regulators, the same battery charging current will flow whether battery is low and really needs the charge, or whether it is fully charged and at the time being distructively overcharged; this point is easily seen for the regulation itself depends upon this charging current. This applies to all regulators except the combination current and voltage types. The matter of setting the regulator then becomes of great importance, and should be given careful thought by the man in charge of axle equipments. It is probably true, that more batteries have been ruined by setting the regulator too high in an effort to be on the safe side than from any other cause.

Some of the things to be considered in setting a regulator are, is the car a parlor car, a dining car, a coach, a mail car or a baggage car; what kind of a run it is on; is it on a through train that runs day and night, is it on a night run train that leaves in the evening and reaches its destination early in the morning or is it on an accommodation train that makes most of its run in the daytime; is it on a diner that has a short run and a heavy discharge both before the train leaves and after it arrives at its destination, as well as all the time on the road. All this simmers down to this—you have got to get an idea of the total number of ampere hours discharge which the car is apt to receive, including time of stop and lay overs, and also all time when the train runs at a speed below cutting in speed of the generator, as on mountain divisions, passing through yards, approaching the terminal, etc. This is not as difficult as you might think, for if you simply place a duplex train ampere hour meter in the battery circuit, you can get a good idea of not only the amount of discharge which the car receives, but also the amount of charge.

Rule for Setting Regulators.

It is impossible to lay down a rule for setting regulators that will fit every case. It is at best only on approximation. But in general, for those regulators which maintain constant generator current and have no differential windings, the regulator should be set so that the aggregate ampere hour charge during the daylight run will be about twice as great as the total number of ampere hours discharge at slows and stops during the night. This should be sufficient to care for low battery efficiency and for all regular and some emergency discharges. In making this calculation, don't forget to take into account the all-night charge. This may vary but is usually of low value and in some cases may be a slight discharge, but it should be taken into consideration which ever way it is.

The calculation for the proper setting of a battery current regulator of the Bliss type is more simple and of a smaller probable error. Since the charging current is proportional to the average train speed, or more correctly is proportional to the average train speed above the critical speed, all that is required in setting this regulator is to know the average train speed from the time table, the total battery discharge in ampere hours while the generator is not operating, and the total time the generator is operating. The regulator is then adjusted, when the average train speed is attained, to such a value that the then obtained current multiplied by the total time that the generator is operating will give an ampere hour charge equal to about twice the total ampere hour discharge. This will ordinarily be sufficient to allow for low battery efficiency and for recovery from emergency discharges. It should be noted that no consideration need be given to the number of lamps used nor the hours of lighting, this battery charge being entirely independent of the lamps.

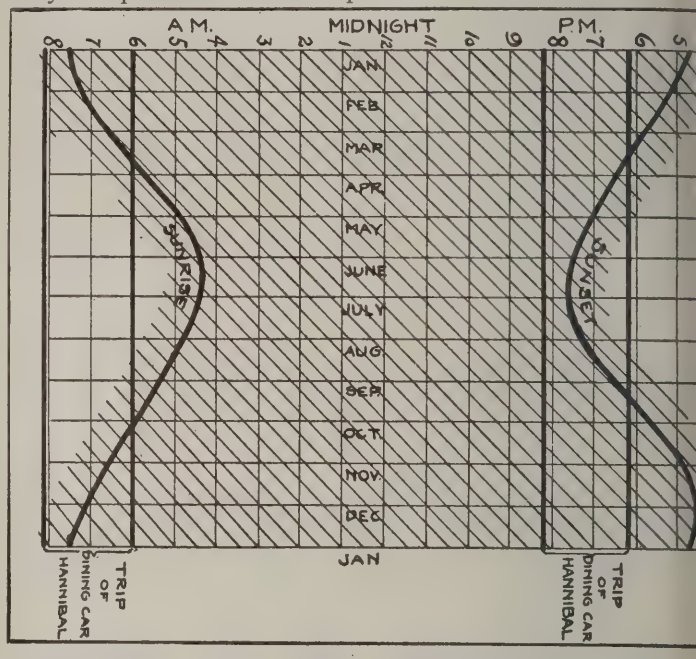


Fig. 35. Showing Variation of Hours of Lighting Throughout the Year.

Where the combination voltage and current regulators are installed, they automatically take care of themselves, so that no adjustment of the regulator is necessary. Although these equipments have not been in use very long it looks as if they are going to greatly simplify the troubles of the axle lighting man.

Change of Setting at Different Seasons of the Year.

There is a big difference in the amount of discharge car lighting batteries receive in the winter time and that of summer time. Fig. 35 shows the curve of sunrise and sunset for the various months of the year, the shaded portion indicates night figured as an hour before sunset till an hour after sunrise. It should be noted that in June there is about 10 hours lighting, while in January the lamps will have to be lighted 17 hours. This means an increase of 70 per cent in the lighting hours of January over June. Obviously, regulators should be set to compensate for this variation, but of course they will not, except in special cases, be increased anything like 70 per cent.

For constant generator current regulators which have no differential winding, it is readily seen that the increased total hours of lighting will affect the operation in two ways; it will increase the probable battery discharge at stops, and will decrease the total hours of charging the battery during the day. The battery discharge will increase directly proportional to the 70 per cent increase in the hours of lighting, while the battery charging will decrease with the decrease in daylight hours for charging the batteries. This decrease in charging is 7 hours or about 50 per cent of the total hours available for charging outside of lighting hours

during June. The increase in lighting hours is 7 hours or 70 per cent increase over June lighting. These these combined would require an increase to 3½ times the normal rate of charge, or a 250 per cent increase, if all the charge were to be done during the seven hours daylight run in January. This increase in setting, however, will be effective throughout the whole twenty-four hours run, instead of only seven hours upon which that figure is based, so the necessary increase in the average charging current will be only about 100 per cent.

It has been found that the battery charge generally comprises about ¼ of the total output of the generator, so that reducing the calculation to a basis of generator current, it is found that: For all constant current regulators operating on trains having a 24-hour run or over, *the regulator adjustment should be increased approximately 25 per cent* for operation in January over that for operation in June.

For regulators operating on principles of battery current control the situation is somewhat different. As previously indicated, the charging of the storage battery takes place all the time the train is above critical speed and is independent of the lamps. Now again, assuming the car is operated on a 24-hour run, the increase of 70 per cent in the hours of lighting during the winter months will only affect the battery discharge and will not affect the charge, so that the re-adjustment of the regulator need be only such as will compensate for the increased discharge. However, inasmuch as the battery current comprises the total regulator current, this increase of 70 per cent in the battery discharge must be compensated for by a direct increase of 70 per cent in the regulator setting.

In the above examples it has been assumed that the train was an overland train that ran at least a day and a night. Where equipments are operated on short runs, conditions may be entirely different. The heavy horizontal lines shown in Fig. 35 mark the trip of the dining car Hannibal, the evening run being from 6:10 p. m. to 8:15 p. m., and the morning run from 6 a. m. to 8:05 a. m. It is seen from the curve that in summer time the lamps are lighted for but 1½ hours for each round trip, while in the winter time they are lighted not only for the entire run, but all the time the car lays in the station, and in fact for a good part of the afternoon in the coach yards as well. This probably will amount to a total of about 6 hours which is 4 times the amount of light used in the summer time.

THE STOP CHARGE RELAY.

For several years past, the manufacturers of all the various axle equipments have installed stop charge relays in connection with their equipment, which consist of small solenoids placed across the generator terminals and adjusted so that when the battery voltage raised to a certain point it would close the relay and partly kill the generator so as to stop the charging. This sounds fine, and in many cases may be found to work perfectly satisfactorily for a time; but the experience of the last two years has forceably demonstrated the fact that these relays don't always work right, and even if they do work right themselves, the battery voltage may vary and is not a safe guide. The voltage indication which you get with a voltmeter across the terminals of a battery deepnds upon what charging current is flowing into that battery, the higher the charging current, the higher the voltage; it also depends upon the temperature, when a battery is cold it will take a much higher voltage to charge it full, than when it is warm; it also depends on the condition of plates, a sulphated battery will show a voltage much higher than normal.

Stop charge relays may be all right if they are properly handled—don't set them too high, otherwise they may not open at all, and although your battery will come back fully charged, it will probably be injured by severe overcharging, a condition which is pretty hard to detect until battery goes to pieces. If you set them low enough, say 43 volts, so that they will be sure to operate, then once every 10 days or 2 weeks cut out the relay, so that the equipment will overcharge the battery and break up any slight sulphation that might have occurred, you will find that the stop charge relay will give much better service than when it is depended upon absolutely.

Setting of the Stop Charge Relay.

To set the relay, first let it get thoroughly warmed up. The resistance of the copper wire in the coil is slightly higher when warm than it is when cold, and if the relay is set cold it would not operate until too high a voltage when placed in actual service and the coil becomes heated.

To do this add a few dry cells in series with the storage battery until the voltage of the combination reaches 43 or 44 volts, then adjust the relay so that it operates at that point.

(To be Continued.)

Practical Stunts.

Send in Your Ideas, We Pay for Them.

For the past few years we have been using tar paper to shim up the axle when axle pulleys are applied. We have found that in hot weather the tar will ooze right out of the paper under the great pressure with which the axle pulley is bolted down. This has given us some trouble in axle pulleys coming loose. We now use ordinary paper, usually old railroad time tables and find them very satisfactory

H. G. MEYERS, Santa Fe.

Very often hard rubber separators and side sheets become brittle, especially when cold. It is a good scheme to soak them in hot water for a few minutes before installing, or if trouble is experienced in removing separators from cells that are to be cleaned, the same effect may be produced by turning live steam right into the cell until it is warmed up, then allow it to stand for a few minutes and the separators will be found to be flexible and can be handled without any danger of breaking.

BERT PECHALY.

PAPER ON FREIGHT HANDLING SYSTEMS.

Mr. H. McL. Harding will deliver a paper before the Western Railway Club on the subject of the Telpher system as applied to handling of material in railway freight houses and shops.

On account of the many labor troubles in conncetion with handling freight very recently, as well as purely from the standpoint of saving in cost, this subject is of particular interest to railroad men.

Mr. Harding has made a very extended investigation of this subject and has found that freight may be handled at an average of 20c. per ton by the Telpher system as against 85c. per ton by hand. Without a doubt a similar saving can be shown in handling materials in railroad repair shops. Everyone interested is invited to attend the meeting which will be held at 8 P. M., October 15th, at the Auditorium, Chicago, Ill.

Field Control on the Pennsylvania Railroad Locomotives.

An aggregate delay of but thirteen minutes chargeable to electrical apparatus on thirty-three locomotives for a year is indeed a remarkable showing. This is exactly the performance of the Westinghouse locomotives in the service of the Pennsylvania Tunnel and Terminal Company out of New York City. During the year 1911 the milage given below were made by these locomotives:

Total locomotive miles.....909,238
Maximum miles per locomotive..... 56,000
Average mileage per locomotive..... 25,975

Thirty-three of these engines operated for a year with the phenominal record of only thirteen minutes delay chargeable to electrical troubles.

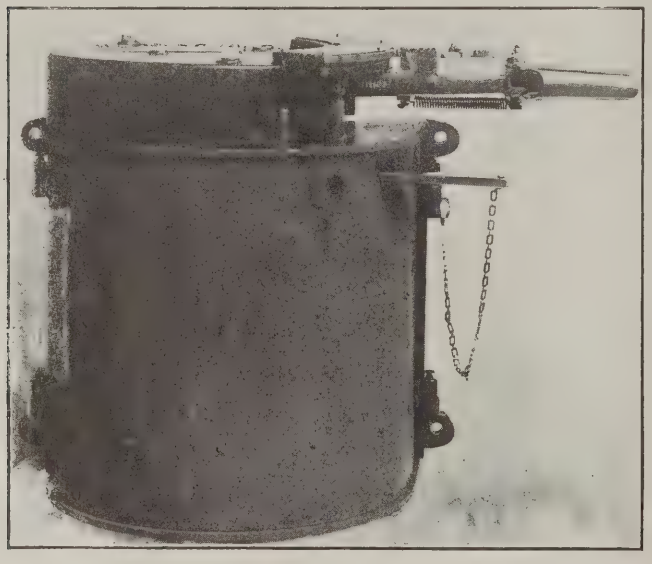


Fig. 1. Master Controller of Locomotive.

The control of these locomotives is of interest not only because of this excellent maintenance record but also because of several unusual features described below, that are incorporated in it.

In the early days of electrical traction the method of controlling motors by shunting their fields was applied, but finally abandoned due to the poor operation of the pioneer motors. Later the Westinghouse Company developed commutating-pole railway motors for field control that commutate and operate successfully. The New York, New Haven and Hartford Railroad used shunted field control for direct-current operation on its original locomotives. While the Pennsylvania R. R. locomotives were constructed a special type field control was developed for controlling the large 2000 h.p. commutating pole motors which drive them.

The field of each motor of the Pennsylvania locomotive is divided into two parts and in both series and parallel running there are two running points, one with maximum or full field and the other with normal or half field in circuit. In each case there are two transition positions between full field and normal field positions in which the resistance is shunted across the motor fields. Thus these locomotives have four running positions.

Each locomotive consists of two units each complete in itself and interchangeable so that at any time either half of any locomotive may be coupled to any other half locomotive.

The handle of the master controller (Fig. 1) is arranged to have but a comparatively small amount of travel, similar to that of a steam locomotive throttle; however, by means of a gear connection, this small movement is multiplied in transmission to the controller drum.

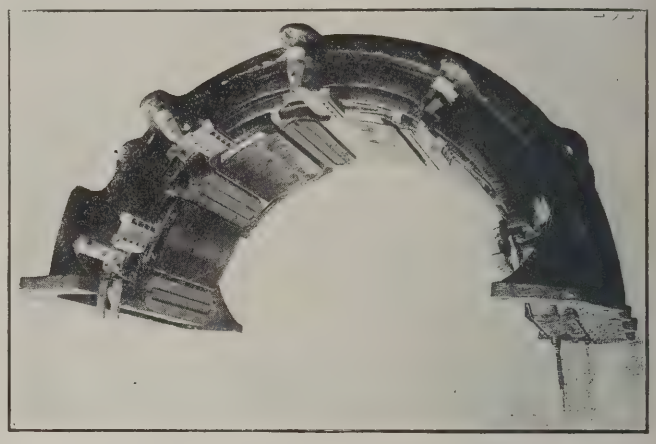


Fig. 2. Upper Half of Generator Fields.

An extremely quick-acting circuit-breaker (Fig. 3) is used. By means of its size it operates differently from the ordinary line switch or circuit-breaker, in that it can be tripped without first releasing the air from the main cylinder. By its quick action the extent of damage from short circuit is greatly decreased. This main circuit-breaker is of high capacity and may be opened or closed by opening or closing the low voltage circuit which leads to the magnet valve and admits compressed air to the operating cylinder, or it may be opened automatically by means of the magnetic trip. The motor current

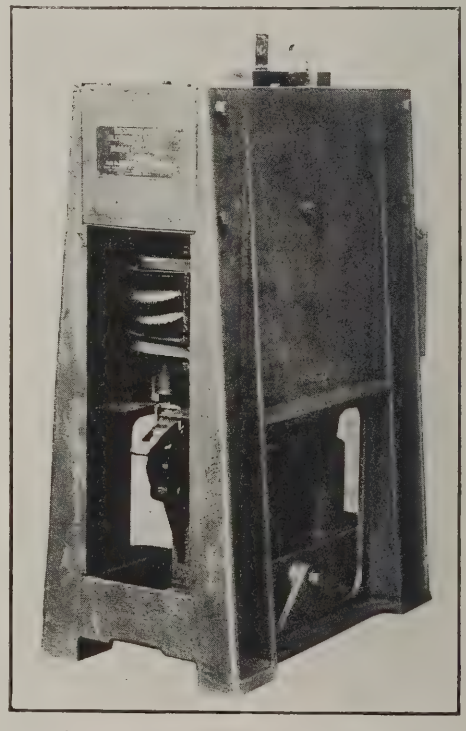


Fig. 3. Quick Action Circuit Breaker.

passes through the coil of this tripping magnet and if the current through the circuit-breaker becomes higher than that for which the breaker is adjusted the plunger lifts and striking against the trip, causes the breaker to open. The movement of the main contact when opening

and closing is the same as in Westinghouse unit switches, but the operating mechanism is different. The movable contact arm is not connected directly to the piston rod, but to the upper end of a guide rod operated by a vertical movement of this rod which is connected through a system of levers to the piston of the operating cylinder on one side and to the overload device on the other side through a tripping lever.

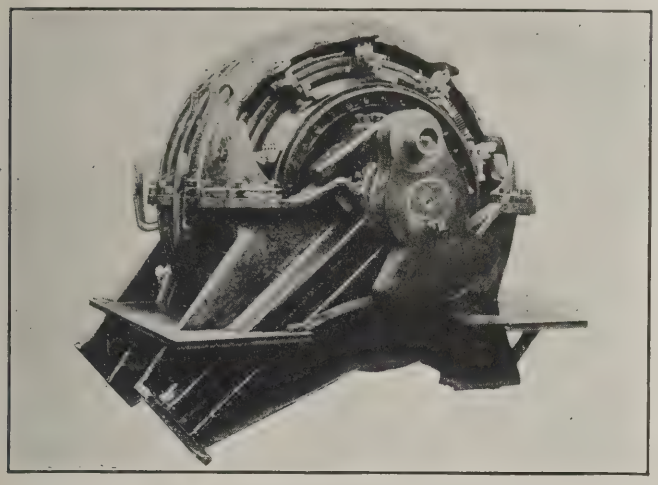


Fig. 4. One of the 2000 h.p. Motors.

These circuit-breakers are enclosed in iron cases. The arc chute in which the main contacts are contained is open so as to give plenty of room for the copper gases to vent when the breaker opens from exessive current. Powerful blow-out magnets are located on each side of the arc chute opposite the contacts. The circuit-breakers are located one on each locomotive unit, near the cab partition adjacent to the switch groups, the arc chute venting toward the center passageway between switch groups.

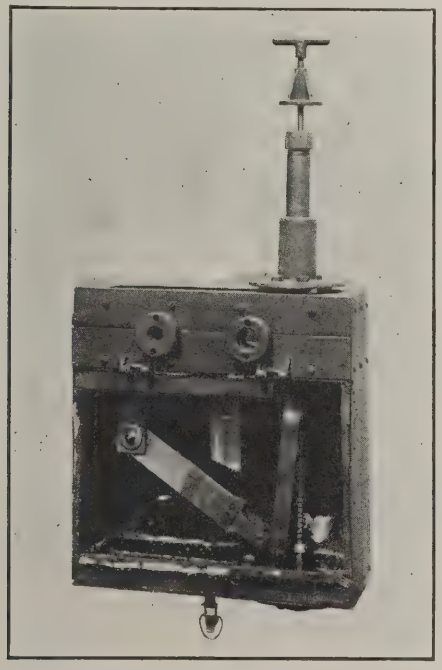
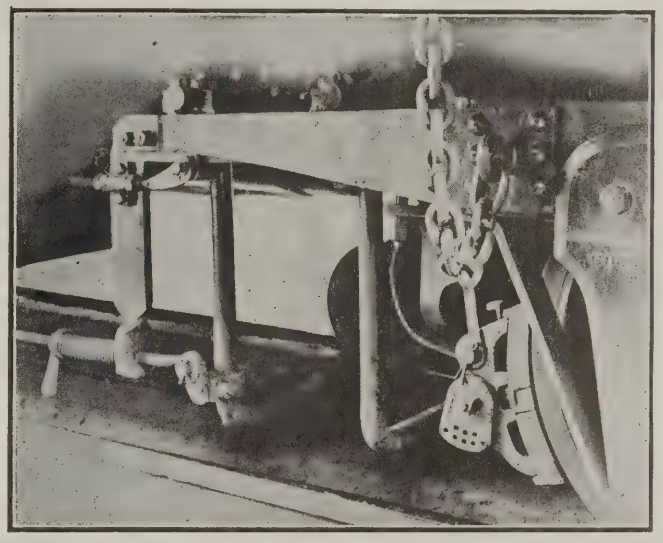


Fig. 5. Short Circuiting Emergency Switch.

As an emergency provision in order to kill the third rail for any reason, a short circuiting or grounding switch is placed on each half of the locomotive. It is operated by a pull lever projecting through the floor on the left side of cab. The closing of this switch, unprotected by fuses, causes a dead ground which is ample to trip the breakers at the sub-stations and thereby cut off power.

NEW TYPE SUSPENSION IRONS.

The accompanying illustration shows a new type of generator suspension recently designed by the Illinois Central Railroad Co. Instead of using simply 4 inch iron bars passing either over or through the end sill, as has been past practice, the side irons are reinforced by heavy irons rivited solid to the truck sill as shown. This tapers from 3 inches at the end to 7 inches at the base so it reinforces the generator suspension very strongly. The suspension loops are bushed on the end and ride in a bearing bolted to the top of the saddle iron as shown. The busings take the slight wear caused by vibration of the generator when going at high speed, so that when it becomes necessary to make renewals, the bushings only need be renewed.



New Reinforcement of Generator Suspension.

CONDENSITE.

The rapidly increasing uses of molded insulation has caused this subject to become one of vital importance to all electrical men. An excellent paper read before the 1911 Convention of the Association of Railway electrical Engineers by Mr. K. R. Sternberg, covered this subject in a most complete manner. The demand for a heat resisting insulation having high mechanical strength. yet easy to machine, such as are the properties of Condensite, has been so great, however, that a further description of this product will be of interest to our readers.

Condensite is the latest development in molded insulations. It is a high grade plastic which can be readily molded into any desired shape before being treated. A treatment with heat and pressure however, causes it to have some remarkable properties. It then becomes very hard and tough and has heat resisting qualities to a remarkable degree. It is mechanically far stronger than, yet takes the beautiful polish of hard rubber. Metal parts can be molded into it and it can be tapped, sawed or drilled very easily without injuring the temper of the tool.

The recent demand for moulded insulations has been so great that the Dickinson Manufacturing Co., one of the manufacturers of this product have been compelled to greatly increase the size of their plant, adding 30 new hydraulic presses and an additional accumulator and high pressure pumps.

This increase in facilities makes the Dickinson Mfg. Co., one of the best equipped and most modern plants in the world producing high class molded electrical insulation.

In addition to Condensite, this firm also makes Sternoid, which was the pioneer heat resisting insulation, and is approved by the underwriters, Stern-asbeston, and other hard rubber substitutes.

H. G. MEYERS OF THE SANTA FE MARRIED.

As official scribe we have one other interesting note to report—Mr. H. G. Meyers, Elec. Foreman of the Santa Fe with headquarters at Chicago, has just been married to a young lady from Denver, Colo. Mr. Meyers is well known among all the car lighting boys and his many friends will join us in our congratulations.

E. J. YOUNG APPOINTED ELECTRICAL ENGINEER N. T. R. R.

Mr. E. J. Young has just been appointed electrical engineer of the National Transcontinental Railway with Railway headquarters at Transcona, Manitoba.

AUTOMATIC ELECTRIC CO., TO MAKE RAILWAY TELEPHONES.

The Automatic Electric Company of Chicago will begin the manufacture of auto-mannual telephone apparatus for railway train dispatching service.

The new selector will contain some of the principles embodied in the automatic telephone exchange mechanism that has been so succesful in its operation in telephone exchanges.

Mr. J. H. Finley, formerly of the Western Electric Co., will take charge of the railroad sales, and will have the title of Railway Telephone Engineer.

CONVENTION OF TRAVELING ENGINEERS ASSOCIATION.

The 20th annual convention of the Traveling Engineers Association was held at the Hotel Sherman, August 27-30, 1912. The committee reports and papers cover feed water treatment, coal analysis, the mechanical stoker, handling of trains, electric headlights, etc.

NEW WAY OF HANDLING PIG IRON.

Heretofore the practice of handling furnace pig iron with electromagnets has been limited by the quantity that could be lifted under the ordinary plan of picking the iron from the ground or floor. With the pigs lying flat, only a relatively small number adhere to the magnet. At the Zenith furnace in Minnesota experiments have recently been made with stacking the pigs vertically, standing each pig erect on end. This arrangement allows a greater number of pieces to make direct contact with the magnet pole-pieces, and the lifting capacity of the magnet is correspondingly increased. In fact, with a given magnet which was able to pick up only 1000 lbs. of pigs lying flat, 2000 lbs. can be lifted if the pigs are stacked vertically on the floor. This doubling of the lifting capacity of the magnet is attained with but little added expense for labor in stacking the pigs .

NEW N. E. L. A. BULLETIN.

The engineering department of the National Electric Lamp Association have recently issued a new bulletin, describing in detail the excellent facilities of the National Association for testing and technical researching.

The National Electric Lamp Association is maintained by the various companies formerly constituting that Association as a commercial organization, although on the new basis the Association is maintained merely for the purpose of obtaining more accurate and scientific methods of testing and improving their product.

The Bulletin shows many views inside of the laboratory which will be of special interest to any one not having had the opportunity of visiting the laboratory personally. It is available on request.

INDUSTRIAL LIGHTING BULLETIN.

Bulletin No. 10 on Industrial Lighting, published by the Benjamin Electric & Mfg. Co., of Chicago, contains some good information on shop lighting fixtures. It shows a comparison of the tungsten lamps in different type reflectors, also comparison of tungsten types and arc lamps.

Distribution curves and illumination curves are given, showing the characteristics of the big line of shop fixtures manufactured by that company.

This ought to be in the hands of all men in charge of railway shop lighting installations. Copy gladly sent on request to the manufacturer.

POSITION WANTED.

A party having 14 years experience as sales engineer in dealing with mechanical and electrical officials of the leading railroads of both U. S. and foreign countries desires to represent a manufacturer or supply house.

The coming convention of the Association of Railway Electrical Engineers, October 21-25, also makes this an opportune time to open a big campaign for electrical business on the steam railroads.

Address, K-34, Railway Electrical Engineer.

Ampere Hour Meters

The saving in charging current alone that is made by an ampere hour meter where used in car lighting service will pay for the cost of the meter in two or three months.

Add to this the big saving in battery depreciation when overcharging is eliminated and you will agree that an ampere hour meter ought to be on every electric lighted car.

Write for descriptive matter and prices on the new "Variable Resistor" type for axle equipments.

Sangamo Electric Co.,
Springfield, Ill.

RAILWAY ELECTRICAL ENGINEER

Official Journal
of the Association of Railway Electrical Engineers.
PUBLISHED MONTHLY BY
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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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Statement of the Ownership and Management of Railway Electrical Engineer published Monthly at Chicago, required by the Act of August 24, 1912.

NOTE—This statement is to be made in duplicate, both copies to be delivered by the publisher to the postmaster, who will send one copy to the Third Asst. Postmaster General (Division of Classification), Washington, D. C., and retain the other in the files of the post office.

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NONE.

(Signed) EDWARD WRAY,
Publisher.

Sworn to and subscribed before me this 1st day of Oct. 1912.

(Seals) M. M. FREIDERG,

Form 3526 5-6012 (My Commission expires May 12, 1914.

Brake Beam Troubles.

It often becomes a very knotty problem, especially in the fish-belly girder type car construction, to adjust the suspension of the axle generator so as to allow sufficient clearance between the girder and machine at the same time have the belt clear the brake beam. In extreme cases it has been necessary to lower the suspension to such a degre that the lower side of the belt passes under the brake beam. In other cases when this is not done, the clearance between the belt and brake beam may be so small that when the brakes are set the brake beam may raise so as to actually rub against the belt. This is probably the cause of a large number of belts being torn apart and lost.

There is only one brake shoe to each car wheel, and it makes little difference to which side of the car wheel that brake shoe is applied. By a slight alteration in the levers of the brake mechanism, the brake beam adjacent to the axle generator can be reversed so as to bear on the opposite side of the car wheel. This will simplify to a great degree the problem of the axle lighting men and the saving in belt maintenance will more than warrant the change. We beleve this is a subject worthy of consideration, in fact, one that should be made as a recommendation by the Committee on Standards.

An Ampere Hour Meter for Axle Equipments.

The very recent development of the variable resistor type ampere hour meter as described in another part of this issue now makes it possible to use the ampere hour meter in connection with axle equipments; not only as an indication or check on the operation of the equipment, but as a controlling principle.

In other words, this meter makes it possible to operate the storage battery of an axle equipment on the ampere hour principle of control instead of the current control, voltage control, or combination voltage current control as in use at present.

We believe this development to be of fundamental importance to all car lighting men, both railway men and manufacturers.

Control of Battery Charge.

The recent developments in axle generator regulators which operate on a combination current and voltage principle of control presents a new problem, or at least a problem which has other considerations involved than those of the original constant current regulators or the same with a stop charge relay feature. This new phase of the car lighting problem should receive the careful consideration of all operators of car lighting equipment.

For the basis of all logical thinking on any of these problems, we must go right back to the operating characteristics of the storage battery itself. That is not only the thing to be protected and properly charged, but it is the big controlling feature in the system upon which the successful operation of any of these devices must depend.

It is well known that when charging a storage battery the voltage rises slowly until about three-fourths fully charged, when it begins to rise rapidly and finally reaches a maximum value. This abrupt rise in voltage to a maximum value forms the basis of operation in the new voltage controlling regulators as well as with the stop charge relays heretofore used, but the improvements in design of the newer devices makes it possible to obviate many of the disadvantages of the stop charge relay. These new de-

vices should give much more satisfactory operation if properly adjusted.

The actual value in volts or volts per cell of this maximum however, may vary considerably. It depends (1) upon the current flowing, (2) upon the temperature of the electrolyte, (3) upon the condition of the battery, i. e. whether any of the cells are sulphated, partly short circuited, etc. In short, intelligent discretion must be exercised wherever this overcharging voltage is depended upon for limiting the battery charge.

Since the first application of the stop charge relay, we have always contended in these columns that this device should not be depended upon as the sole means of controlling battery charging since the voltage of a storage battery is no real criterion of its condition of charge. The experience of the best few years moreover has vindicated our position in this matter. In many cases the relays have cut in too soon, resulting in sulphation of the plates. In other cases the battery voltage failed to raise to the setting of the stop charge relay, resulting in a continued overcharge of the battery and serious injury to the plates.

Many stop charge relays are in operation today, but they should be set low enough so that they will always work (even though they have cut in too soon) and a periodical overcharge every week or two being provided by cutting out the relay for one trip.

With the new voltage current regulators however, this same idea of low cut-off with some overcharge may be accomplished automatically, in fact, this is made an inherent part of the operation of the device. Where these devices are employed it will be found good practice to have the maximum voltage value set low enough so the device will always operate; the taper charge will be sufficient in most cases to bring the battery up to full capacity.

It should be noted however, that there are three distinct types of voltage current regulation possible: 1st, a taper charge in which the full charging voltage of the battery is maintained by the generator; 2nd, a quick taper charge in which the generator voltage is reduced slightly after the critical voltage is maintained; 3rd, a complete cut-off after voltage coil becomes operative by reducing the generator voltage to the floating voltage of the storage battery. Obviously, the first and second types may produce a certain mount of overcharge of the battery. Whether or not this will be detrimental is yet to be determined. The third or floating voltage type seems to contain most of the inherent objections of the stop charge relay, and when it is used, the same difficulties of operation that have gone with the stop charge relay must be expected.

This is in no way a condemnation of any particular type of equipment, but rather a consideration of principles. Any manufacturer designing their equipment for operation on the floating voltage principle can very readily raise that voltage slightly to give a quick taper charge or maintain it at maximum value giving the longer taper charge.

Fifth Annual Convention of the Association of Railway Electrical Engineers.

Auditorium Hotel, Chicago, October 21--25.

The Fifth Annual Convention of the Association of Railway Electrical Engineers is to be held in the big exhibit hall on the 9th floor of the Auditorium Hotel, Chicago, October 21-25.

The officers of the Association of Railway Electrical Engineers are:

President.

F. R. FROST,

Electrical Engineer, Santa Fe, Topeka, Kans.

First Vice-President.

D. J. CARTWRIGHT,

Electrical Engineer, Lehigh V. R. R., Philipsburg, N. J.

Second Vice-President.

C. R. GILMAN,

Chief Electrician, C. M. & St. P. Ry., Milwaukee, Wis.

Secretary

JOS. A. ANDREUCETTI,

Gen'l. Foreman, C. & N. W. Railroad, Chicago, Ill.

Executive Committee.

L. S. Billau, Asst. Elec. Engr., B. & O. R. R.
E. W. Jansen, Elec. Engr., I. C. Ry.
A. J. Farrelly, Elec. Engr. C. & N. W. Ry.
H. C. Meloy, Chief Electrician, L. S. & M. S. Ry.
F. E. Hutchinson, Chief Elec., C. R. I. & P. R. R.,
C. J. Causland, Chief Elec., Penna. R. R., Chicago, Ill.

All entertainment and exhibit features of the Convention have been arranged by the Railway Electric Supply Manufacturers Association.

Officers of this Association are:

President.

Geo. H. Porter, Western Electric Co., Chicago.

Vice-President, East.

H. G. Thompson, Jr. Edison Stge. Bat. Co., Orange, N. J.

Vice-President, West.

W. F. Bauer, U. S. Light & Heating Co., Chicago.

Secretary.

J. Scribner, General Electric Co., Chicago.

Treasurer.

Edward Wray, Railway Electrical Engineer, Chicago.

Executive Committee.

R. M. Newbold, Adams & Westlake Co., Chicago.
J. M. Lorenz, Central Electric Company, Chicago.

Otis B. Duncan, J. Lang Electric Company, Chicago.
G. H. Atkin, Electric Storage Battery Co., Chicago.
W. E. Ballatine, Willard Storage Battery Co., Chicago.
J. G. Van Winkle, Safety Car Htg. & Ltg. Co., Chicago.
C. W. Bender, National Elec. Lamp Assn., Cleveland, O.
B. L. Winchell, Jr. Kerite Ins. Wire & Cable Co., Chicago.
J. J. Schayer, Niagara Lead & Battery Co., Chicago.

CONVENTION PROGRAM.

Tuesday, October 22.

Morning Session, 10:00 A. M.
Address of President.
Report of Secretary-Treasurer.
Unfinished Business.
New Business.
Afternoon Session—2:00 P. M.
Report of Committee on Data Information.
Report of Commission on Installation of Wiring for Electric Light and Power in Railway Shops.

Wednesday, October 23.

Morning Session—9:00 A. M.
Report of Committee on Improvements.
Report of Committee on Train Lighting Practice.
Afternoon Session—2:00 P. M.
Report of Committee on Shop Practice.
Paper on Application of Steam Turbines to Railway Shop Work, by Ashley P. Peck.
Paper on Industrial Lighting by B. F. Fisher, Jr.

Thursday, October 24.

Morning Session—9:00 A. M.
Report of Committee on Specifications.
Incandescent Lamps.
Rubber Covered Wire.
Rubber Belting for Axle Generators.
Afternoon Session—2:00 P. M.
Report of Committee on Standards.
Paper on Electric Traction by N. W. Storrer.

Friday, October 25.

Morning Session—9:00 A. M.
Discussion on U. S. Postal Car Lighting, Led by Mr. A. J. Sweet.
Report of Auditing Committee.
Election of Officers.
Afternoon Session—2:00 P. M.
8:30 P. M.
Ladies' night for viewing Exhibits.

Visit to Burnside Shops of Illinois Central R. R.
A special train will be placed at the disposal of the Association by the I. C. R. R. This will leave the Van Buren St. Station at 2 P. M.

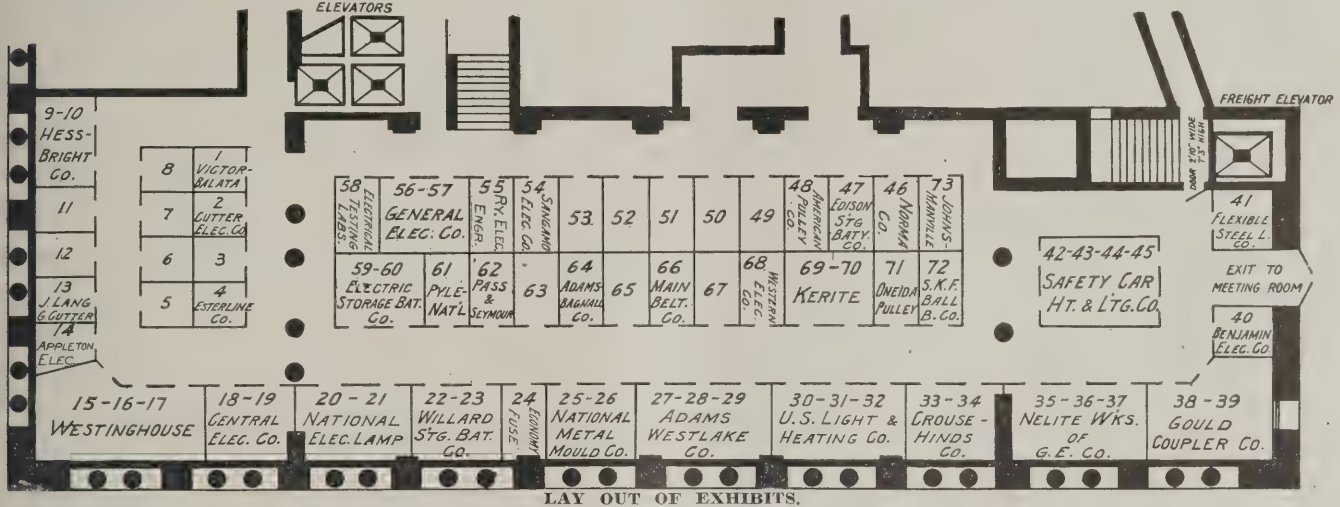
ENTERTAINMENT.

Monday, October 21.

8:30 P. M.
Informal Reception and Dance. Assembly Hall, 9th Floor Auditorium Hotel.

Tuesday, October 22.

2:30 P. M.
Automobile Tour about the City. Tour will start from the Auditorium Hotel at 2:30 sharp, and all ladies holding badges are invited.



LAY OUT OF EXHIBITS.

Wednesday, October 23.

2:15 P. M.
Matinee Party at Olympic Theatre. "The Man Higher Up." All ladies holding badges are invited.

Thursday, October 24.

7:00 P. M.
Fifth Annual Banquet given by the Railway Electric Supply Manufacturers Association to the Association of Railway Electrical Engineers. Various prominent Railroad Officials will be the speakers of the evening with Fredric P. Vose as toastmaster. The banquet will be followed by an informal dance.

LIST OF EXHIBITORS.

	Space No.
Adams-Bagnall Electric Company	64
Adams & Westlake Company	27, 28, 29
American Pulley Company	48
Appleton Electric Co.	14
Benjamin Electric & Manufacturing Co.	40
Central Electric Company	48
Crouse-Hinds Company	33, 34
Cutter Electric & Manufacturing Co	2
Economy Fuse & Mfg. Co.	24
Edison Storage Battery Company	47
Electric Storage Battery Company	59, 60
Electrical Testing Laboratories	58
Esterline Company	4
Flexible Steel Lacing Company	41
General Electric Company	56, 57
George Cutter Co.	13
Gould Coupler Co.	38, 39
Hess Bright Manufacturing Co.	9, 10
H. W. Johns-Manville	73
J. Lang Electric Co.	13
Kerite Insulated Wire & Cable Co.	69, 70
Main Belting Company	66
National Metal Molding Co.	25, 26

National Electric Lamp Association 20, 21
Nelite Works, of G. E. Co. 35, 36, 37
Norma Company of America 46
Oneida Steel Pulley Company 71
Pass & Seymour 62
Pyle National Electric Headlight Co. 61
Railway Electrical Engineer 55
Sangamo Electric Company 54
Safety Car Heating & Lighting Co. 42, 43, 44, 45
S. K. F. Ball Bearing Co. 72
Thompson Electric .....
U. S. Light & Heating Co. 30, 31, 32
Victor Balata & Textile Belting Co. 1
Western Electric Company 68
Westinghouse Electric & Manufacturing Co. 15, 16, 17
Willard Storage Battery Company 22, 23

A Quiet Tip On the Entertainment.

Reception and dance comes off Monday night at 8:30 in the Assembly Hall, 9th floor, Auditorium Hotel.

The automobile tour on Tuesday is for all ladies. It starts at 2:30 p. m. from the ladies entrance of the hotel. Chicago has one of the grandest park-way systems in the world. It is a 50 mile tour of parks and boulevards unsurpassed.

Tuesday night the ladies are expected to say something of an intelligent nature about the exhibits—but here's on the side to the ladies. Some of the manufacturers have already placed orders for a big supply of Bon Bons—and any way, you can be sure they are real salesmen, and it is a secret of salesmenship that if you have the wife of your customer fully convinced of the merits of the stuff you are trying to sell, its dead easy to do the rest, so take it from us you will enjoy yourself Tuesday night.

Wednesday afternoon matinee at the Olympic Theatre, "The Man Higher Up." This is one of the strongest and most interesting plays that has been in Chicago for many a season. A good part of the house has been reserved for the ladies of the Convention.

The annual banquet comes off Thursday at 7 o'clock in the Gold Room of the Congress Hotel. Mr. Frederic P. Vose is to preside as toastmaster, and all of us who were at the banquet last year will know that we have something in the way of a good laugh coming. Chauncy M. Depew in his palmiest days has never been in the same class with Mr. Vose.

Mr. Porter, Chairman of the Entertainment Committee, advises us that he has invited a few railroad presidents and vice-presidents to address us, but all of their talks will be brief. At 9 o'clock we will adjourn and the deck will be cleared for action. The annual ball of the Association will then be held in this place until—well, until we go home.

The committees in charge of the various features are as follows:

COMMITTEES RAILWAY ELECTRIC SUPPLY MANUFACTURER'S ASSOCIATION.

Exhibits.
W. F. Bauer, Chairman, U. S. Lt. and Htg. Co.
J. E. Widner, U. S. Lt. and Htg. Co.
G. A. Graber, Kerite Ins. Wire and Cable Co.

Membership.
J. Scribner, General Electric Co.

Auditing.
J. M. Lorenz, Central Electric Co.

Publicity.
Edward Wray, Railway Electrical Engineer.
C. W. Bender, National Electric Lamp Association

Entertainment Committee.
Geo. H. Porter, General Chairman, Western Elec. Co.

Reception, Dance and Banquet.
John J. Schayer, Chairman, Niagara Lead and Battery Co.
L. J. Kennedy, Consolidated Railway Electric Lighting & Heating Co.
J. G. Van Winkle, Safety Car Heating and Lighting Co.
Geo. W. Cravens, Cravens Elec. Co.
A. C. Moore, Safety Car Htg. & Ltg. Co.
H. G. Thompson, Edison Storage Battery Co.
W. P. Hawley, U. S. Light & Heating Co.
B. F. Fisher, Westinghouse Lamp Co.

Speakers.
Geo. H. Porter, Western Electric Co.
W. E. Ballentine, Willard Storage Battery Co.

Theatre Party.
O. B. Duncan, Chairman, J. Lang Electric Co.
A. J. Cole, Westinghouse Elec. and Mfg. Co.
Jos. L. Abt, New York Leather Belting Co.

Auto Tour.
R. M. Newbold, Chairman, Adams & Westlake Co.
W. E. Ballantine, Willard Storage Battery Co.

Badges.
Godfrey H. Atkin, Chairman, Electric Storage Battery Co.
R. I. Baird, Electric Storage Battery Co.
C. H. Jones, General Electric Co.

Ladies Assisting.

Mrs. F. R. Frost.
Mrs. Jos. A. Andreucetti.
Mrs. F. E. Hutchison.
Mrs. Geo. B. Colegrove.
Mrs. A. J. Farrelly.
Mrs. C. J. Causland.
Mrs. W. E. Ballantine.
Mrs. C. W. Bender.
Mrs. B. F. Fisher.
Mrs. R. E. S. Geare.
Mrs. J. M. Lorenz.
Mrs. C. R. Gilman.
Mrs. George A. Graber.
Mrs. R. M. Newbold.
Mrs. Edward Wray.
Mrs. J. J. Schayer.
Mrs. A. J. Collett.
Mrs. Harry Bayless.
Mrs. E. M. Cutting.
Mrs. H. R. Buck.
Mrs. D. J. Cartright.
Mrs. J. H. Davis.
Mrs. A. McGary.
Mrs. W. J. Bohan.
Mrs. J. R. Sloan.

RAILWAY ELECTRIC SUPPLY MANUFACTURERS' ASSOCIATION.

Members

Adams-Bagnall Electric Company.
Adams & Westlake Company.
American Conduit Manufacturing Company.
American Pulley Company.
Appleton Electric Co.
Benjamin Electric Company.
Central Electric Company.
Columbia Incandescent Lamp Company.
Consolidated Railway Electric Lighting & Equipment Co
Crouse Hinds Company.
Cutter Company.
Delta Star Electric Co.
Diehl Mfg Co.
Economy Fuse & Manufacturing Company.
Edison Storage Battery Company.
Electric Storage Battery Company.
Electrical Testing Laboratories.
Esterline Company.
Flexible Steel Lacing Company.
Ft. Wayne Electric Works.
General Electric Company.
George Cutter Company.
Gould Coupler Company.
Hess-Bright Manufacturing Company.
H. W. Johns-Manville Company.
Independent Lamp & Wire Company.
J. Lang Electric Company.
Kerite Insulated Wire & Cable Company.
Main Belting Company.
National Metal Molding Company.
National Electric Lamp Association.
Nelite Works of the G. E. Company.
Geo. P. Nichols.
Norma Company of America.
Okonite Company.
Oliver Electric & Manufacturing Company.
Oneida Steel Pulley Company.
J. H. Parker.
Pass & Seymour.
Perkins Electric Switch Mfg. Co.
Pyle National Electric Headlight Company.
Railway Electrical Engineer.
W. C. Robinson & Sons.
Safety Car Heating & Lighting Company.
Sangamo Electric Company.
S. K. F. Ball Bearing Company.
Sprague Electric Works.
Thompson Electric Co.
United States Light & Heating Company.
Victor-Balata & Textile Belting Company.
Western Electric Company.
Westinghouse Electric & Manufacturing Company.
Willard Storage Battery Company.

THE REPORTS OF THE COMMITTEES

The Association of Railway Electrical Engineers assumes no responsibility for the individual views of its members on the various topics and disavows any action taken on the various subjects except such action as is taken in due course and accordance with the constitution.

Report Committee on Data and Information

The Committee on Data and Information for 1912 in their last paragraph recommended that there be some discussion as to subjects which the Association would like the next Committee to work on, but this discussion did not take place and we find ourselves in the same position as the last Committee.

We have again written all the railroads shown in last report as to information concerning electric lighted cars they have in service this year. It has been difficult to get replies and where our request was not complied with we used the report of last year.

We submit a form or estimate sheet of car wiring which we think will be a benefit to members in making estimates on wiring new cars or cars that are to pass through the shops and be eelctric lighted.

Suspensions.

We feel that one of the most important points to be considered in placing axle light equipment on the car is a good suspension and the method in which the suspension is attached to the truck.

A good many have considered extending the sides of the truck a distance of twenty-six or twenty-eight

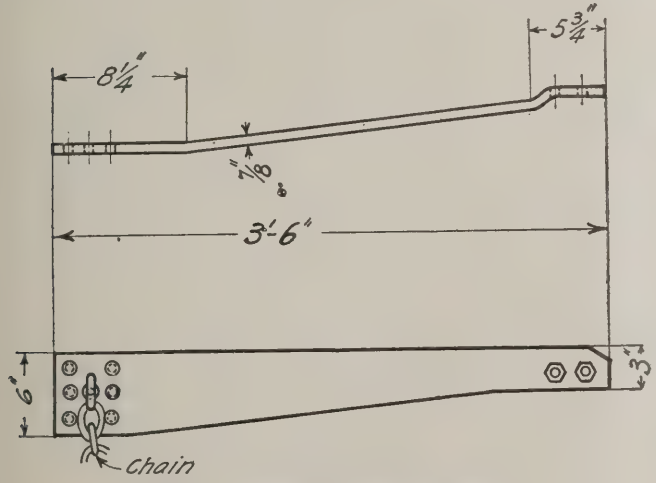


Fig. 1. Diagram of Suspension Brace.

inches, but to do this would make a great deal more expensive casting and the end sill would have to be dropped a great deal lower to pass under the center girder of steel car.

On cars with steel trucks the suspension should be secured to the truck without any chance of vibration and below is a photograph of the new heavy side brace which is bolted or preferably riveted to the side of the truck and which can be secured to the suspension iron at its outer end on any of the standard equipments.

A sketch of this brace is also shown with holes for bolting on the truck.

Any piece of metal may have a flaw and a suspension iron should be more firmly supported or strengthened than is done by the ordinary inside or outer brace of smaller size.

These heavy side braces can be three-fourths or seven-eighths inches thick and are stronger than the suspension iron proper.

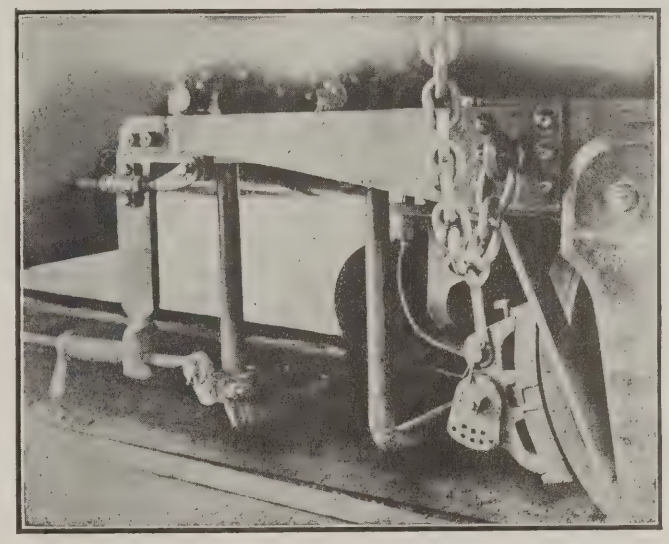


Fig. 2. Suspension Brace Applied to Truck.

It has been placed on four wheel open end steel trucks and also on the standard six wheel steel trucks.

Belts.

It is advisable that where possible large axle and dynamo pulleys be used. This will greatly increase the belt life as is shown by attached statement of belt mileage made on different classes of cars using the highest grade of five inch four ply rubber belt with 11 in. dynamo pulleys and 21 in. axle pulleys.

	Belts Applied.											
	January		February		March		April		May		June	
Class of Cars—	Cars	Belts	Cars	Belts	Cars	Belts	Cars	Belts	Cars	Belts	Cars	Belts
Sleeping Cars....	9—	4	9—	6	8—	3	8—	4	8—	3	8—	3
Dining Cars.....	14—	16	14—	3	15—	6	14—	5	15—	7	15—	2
Buffet Cars.....	15—	7	15—	5	13—	2	12—	2	12—	5	12—	2
Coaches and Baggage Cars.....	69—	12	69—	10	73—	21	72—	8	62—	12	69—	8
Business Cars...	10—	2	11—	2	12—	2	11—	0	12—	1	13—	4
	117—	48	118—	26	121—	34	117—	19	109—	28	117—	19
Average Mileage per Belt.....	25,952		44,032		37,192		59,702		45,155		79,878	

Mileage of cars had not been received at time of writing for July and August but there were one hundred and twenty cars each month and the average

mileage for all cars in July or the same number was 1,278,000 miles.

In July there were applied twenty-five belts or about an average of 51,000 miles and in August eleven belts were applied to one hundred and twenty cars or an average of 116,000 miles per belt.

Light Failures.

A light failure is charged against the cars when they arrive at a terminal with less than twenty-five volts, thirty-five volts tungsten lamps being used.

An average of one hundred and twenty cars were in service each month and reported failures either by yard electricians reports or train conductors reports were as follows:

January	14	Failures or	88,900 miles per failure.
February	6	Failures or	199,000 miles per failure.
March	13	Failures or	101,000 miles per failure.
April	11	Failures or	107,000 miles per failure.
May	7	Failures or	187,000 miles per failure.
June	2	Failures or	661,000 miles per failure.

Number of failures in January was caused by the extremely cold weather which on account of ice on suspensions caused same to stick breaking belts and to also eight straight storage cars which would arrive so late that batteries could not be fully charged to last round trip.

ANALYSIS OF ELECTRIC CAR LIGHTING.

	Cars Lighted by Electricity.	Cars Lighted by other means.	Straight Storage		Cars with Turbine.	Head End System.		Axle Gen. System.		Owned and Operated R. R. Co.	Owned and Operated by Pullman Co.	Cars Contracted For.	No. Cells Head Battery.	Cells Nickle, Iron, Alkaline Battery.
			No.	Volts		No.	Volts	No.	Volts					
Atchison Topeka & Sante Fe	682	1120	0	0	0	0	0	682	30	632	50	50	11552	25
Boston & Albany	5	71	5	26	0	0	0	0	0	5	0	0	28	44
Baltimore & Ohio	246	1105	28	60	11	67	64	19	60	143	103	....	3028	100
	.....	.....	....	.....	.....	....	...	29	30	....	....	....	.....	....
Canadian Pacific	165	2273	....	.....	.....	....	...	128	24	128	....	37	3072	220
Chicago St. Paul Minn. & Omaha	58	265	....	.....	4	....	64	2	60	2	....	....	192	....
Central of Georgia	6	258	....	.....	.....	....	...	6	30	....	....	....	80	50
Chicago & Alton	103	100	56	32/64	.....	....	...	34	32/64	103	....	....	.....	....
Chicago & Eastern Illinois	93	107	2	32	.....	....	...	77	32	79	14	....	1264	....
Chicago Burlington & Quincy	710	591	....	.....	52Cars	52	60	2	30	....	....	....	5508	....
	.....	.....	....	.....	16Eng	16	164	....	.....	....	....	....	.....	....
Chicago Milwaukee & St. Paul	990	368	30	64	58	58	64	9	64	930	....	60-64	3872	....
	.....	.....	....	.....	.....	....	...	2	32	....	....	....	.....	....
Chicago Great Western	70	102	....	.....	.....	....	...	70	30	70	....	....	736	216
Chicago & North Western	672	1000	....	.....	23	200	64	17	60	572	100	....	2200	25
	.....	.....	....	.....	.....	....	...	35	30	....	....	....	.....	....
Chicago Rock Island & Pacific	344	805	....	.....	.....	....	...	301	30	....	....	36-30	5024	125
	.....	.....	....	.....	.....	....	...	6	60	....	....	1-60	.....	....
Cleveland Cinn. Chicago & St. Louis	46	552	2	.....	.....	....	...	44	32/64	103	....	....	....	....
Deleware Lackawana & Western	44	738	....	.....	.....	....	...	44	30	....	30	....	704	....
	.....	.....	....	.....	.....	....	...	1	60	....	....	....	.....	....
Denver & Rio Grande	30	348	....	.....	.....	....	...	29	32	....	....	....	512	....
El Paso & South Western	17	46	....	.....	.....	....	...	17	30	....	....	....	272	....
Erie, R. R.	156	1788	74	30	.....	....	...	72	30	146	....	10-30	2448	....
Great Northern	551	402	11	110	45	550	110	1	30	953	....	....	3040	....
Grand Rapids & Indiana	33	86	28	60	.....	....	...	1	60	33	....	....	912	....
	.....	.....	....	.....	.....	....	...	4	30	....	....	....	.....	....
Grand Trunk	106	.....	....	.....	.....	....	...	15	24	31	75	....	840	....
	.....	.....	....	.....	.....	....	...	15	30	....	....	....	.....	....
	.....	.....	....	.....	.....	....	...	1	60	....	....	....	.....	....
Fort Worth & Denver City	22	31	....	.....	.....	....	...	22	32	....	....	....	336	25
Illinois Central	330	770	10	30	.....	....	...	320	30	240	90	....	2240	3050
	.....	.....	....	.....	.....	....	...	3	60	....	....	....	.....	....
Kansas City Southern	21	57	....	.....	.....	....	...	18	30	....	....	....	384	....
Lehigh Valley	219	340	....	.....	.....	....	...	196	32	....	....	23-30	3480	24
Long Island	113	404	3	64	.....	....	...	109	32	....	....	....	3680	125
Lake Shore & Michigan Southern	139	634	....	.....	.....	....	...	72	30	....	....	....	.....	....
	.....	.....	1	6	.....	....	...	47	60	....	....	....	3312	....
Louisville & Nashville	67	558	1	32	.....	....	...	59	32	....	....	532	1120	75
Missouri Pacific	208	739	1	32	.....	....	...	109	32	....	178	....	1824	....
Mobile & Ohio	6	119	....	.....	.....	....	...	6	.....	6	....	....	.....	....
Minneapolis & St. Louis	19	76	....	.....	.....	....	...	19	32	17	2	....	304	....
Michigan Central	60	438	....	.....	.....	....	...	18	60	....	....	12-30	1248	....
	.....	.....	....	.....	.....	....	...	30	30	....	....	....	.....	....
Minn. St. Paul & S. Ste. Marie	65	328	....	.....	.....	....	...	65	32	....	20	....	1072	....
New York Central & Hudson River	763	970	....	.....	.....	....	...	430	.....	430	400	333	7536	54
New York Chicago & St. Louis	2	.....	....	.....	.....	....	...	2	60	....	....	....	64	....
New York New Haven & Hartford	330	2103	....	.....	.....	3	110	113	30	330	....	36-60	7280	276
	.....	.....	....	.....	.....	....	...	178	60	....	....	....	.....	....
Northern Pacific	667	492	....	.....	53	658	64	9	64	....	....	....	28621	....
National Railway of Mexico	36	.....	....	.....	.....	....	...	31	32	9	22	5	592	....
Norfolk & Western	77	382	....	.....	.....	....	...	13	30	13	30	64	.....	1600
Oregon Short Line	84	198	1	32	6	82	64	1	32	282	82	23	480	....
Oregon Ry. & Navigation Co.	56	55	....	.....	7	55	64	1	60	131	....	....	436	....
Pullman Co.	2400	1864	6	.....	.....	....	...	2400	30	....	....	....	38400	....
Pittsburg & Lake Erie	4	134	1	60	.....	....	...	2	30	....	....	....	96	....
	.....	.....	1	30	.....	....	...	....	.....	....	....	....	.....	....
Perre Marquette	102	259	....	.....	.....	....	...	102	32	102	....	....	1632	....
St. Louis & San Francisco	246	388	....	.....	.....	....	...	236	32	....	76	10	3820	....
St. Louis & South Western	15	208	....	.....	.....	....	...	4	60	....	11	....	304	....
	.....	.....	....	.....	.....	....	...	11	30	....	....	....	.....	....
Southern Ry.	258	.....	....	.....	.....	....	...	228	30	....	....	30	4128	....
Southern Pacific	145	1400	2	.....	.....	71	64	72	32/64	145	....	....	2200	....
San Pedro Los Angeles & S. L.	76	97	1	.....	.....	55	64	20	32/60	24	....	....	608	....
Texas & New Orleans	16	533	....	.....	.....	....	...	16	64	16	47	....	512	....
Trinity & Brazoo Valley	16	12	....	.....	.....	....	...	16	32	....	....	....	176	125
Union Pacific	221	346	....	.....	32Eng	202	63	13	64	221	....	44	2020	64
	.....	.....	....	.....	.....	....	...	6	32	....	....	....	.....	....
Wheeling & Lake Erie	4	72	3	.....	.....	....	...	1	.....	4	....	....	.....	....
Western Pacific	86	.....	....	.....	.....	....	...	85	32	....	....	....	.....	....
	.....	.....	....	.....	.....	....	...	1	64	87	....	....	1392	....
Pennsylvania East	1092	2310	845	60	174MA	....	...	19	60	1226	....	489	53632	2550
	.....	.....	....	.....	.....	....	...	228	60	....	....	....	.....	....
Pennsylvania West	581	717	526	60	.....	....	...	5	30	581	....	54	22592	50
	.....	.....	....	.....	.....	....	...	50	60	....	....	....	.....	....
Van Dalia	53	116	42	60	.....	....	...	11	60	53	....	....	2128	....
Wabash	.....	.....	....	.....	.....	....	...	....	.....	....	....	....	.....	....
Total	13736	29075	1673		481	2073		7100		7749	1310	1324	234069	8018

The accompanying curves on power requirements of machine tools are the results of a series of tests made in the shops of one of the large Western railroads.

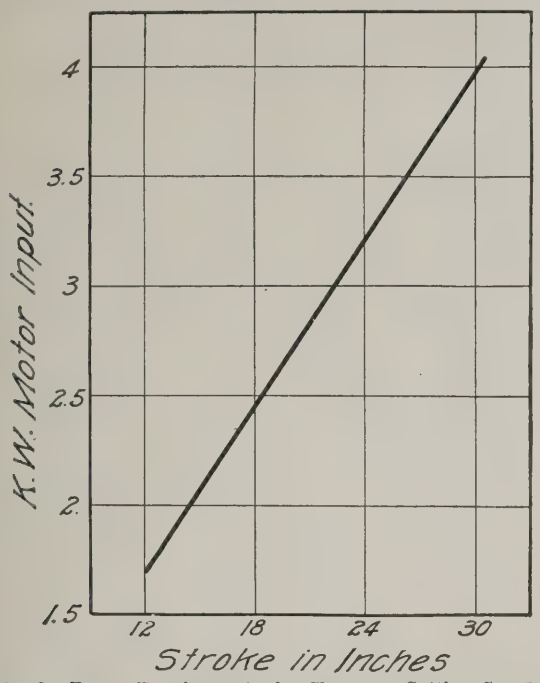


Fig. 3. Power Requirements for Shapers. Cutting Speed 25 Ft. Per Minute.

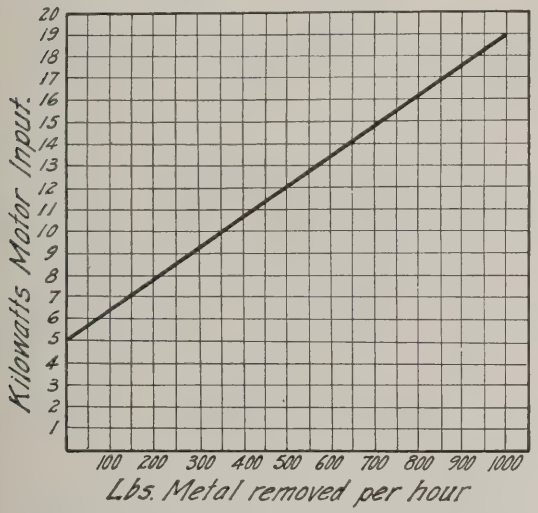


Fig. 4. Power Requirements for 90 in. Driving Wheel Lathe, Cutting Speed 12.5 Ft. Per Minute.

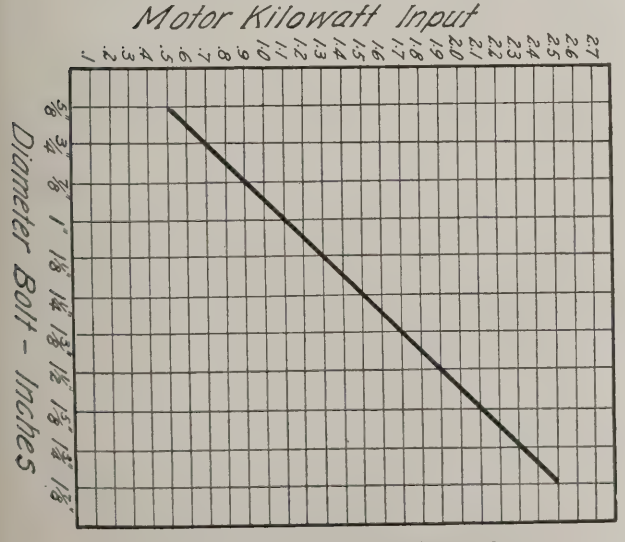


Fig. 5. Single Head Bolt Threading Machine.

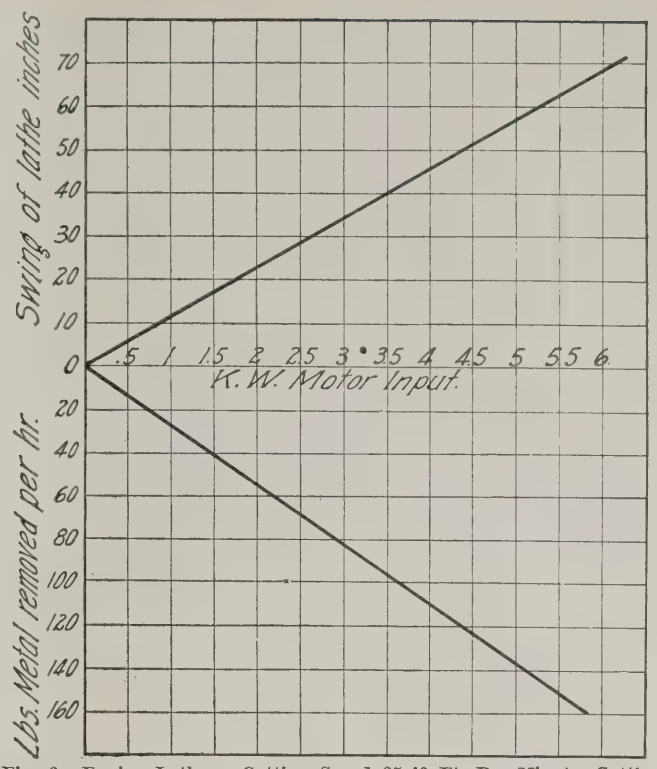


Fig. 6. Engine Lathes. Cutting Speed 35-40 Ft. Per Minute. Cutting Mild Steel; Mushet Tool Steel. (Based on Tests of 24 In. to 60 In. Lathes.)

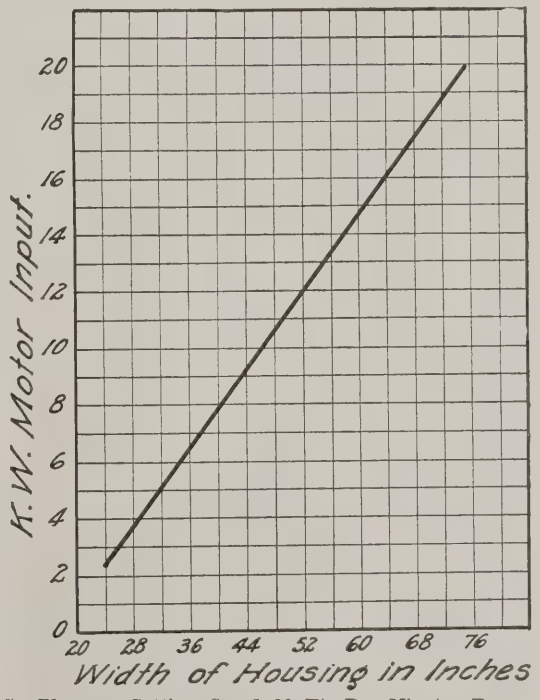


Fig. 7. Planers. Cutting Speed 20 Ft. Per Minute; Reserve, 50 Ft. Per Minute.

ESTIMATING SHEET OF CAR WIRING.

Material.

	Price Per Unit	Price Net
Axle device complete		
Batteries 30 or 60 volt		
Switchboard		
Dynamo suspension		
Battery Box		
Regulator locker		
2 Gibbs 3-G Female connectors		
2 Gibbs 3-G Male connectors		
2 Vestibule hooks to support connecting wires		
2 Type "C" charging receptacles		

"Conduit."

½" .....
¾" .....
1" .....
1¼" .....
1½" .....
2" .....

"Conduit Bushings."

½" to 2" .....

"Pipe Plugs."

E. L. 512 for battery box .....
½" to 2" .....
Floor flanges .....

"Junction Boxes."

E. L. 298 Main under car .....
E. L. 494 single circuit and train line top of car .....
E. L. 495 two line circuit and train line top of car .....

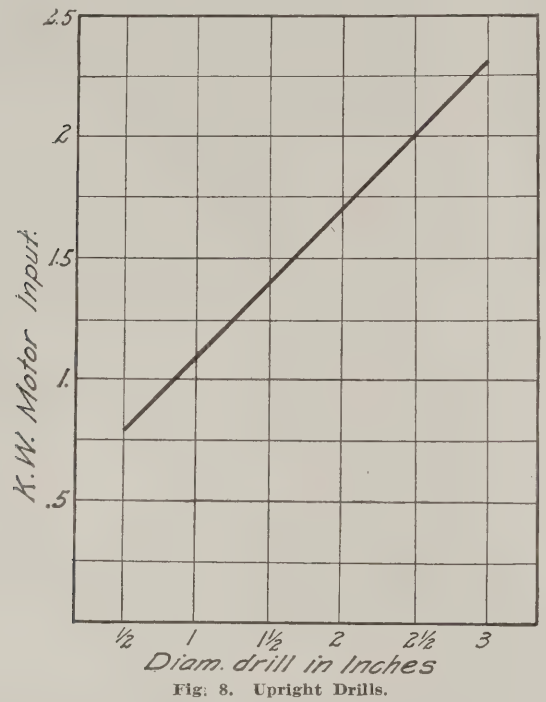


Fig. 8. Upright Drills.

E. L. 496 two line circuit .....
E. L. 272 one line circuit .....
Battery box fuse boxes .....
B condulet at dynamo .....

"Wire."

¼
Train line No. 2 .....
Train line No. 2 flexible .....
Train line taps to switchboard .....
Positive and negative generator leads No. 4 .....
Positive generator field lead No. 8 stranded.....
Positive and negative battery leads No. 4.....
Charging receptacle leads No. 4 .....
Lamp regulator leads No. 4.....
Bell wire .....
Fixture wire .....
Circuit wires .....
Lamp cord .....
Lamp cord silk .....
Tape friction .....
Tape rubber .....

"Wire."

Solder .....
Solder paste .....

"Fixtures."

Remodeling fixtures .....
Speed indicator and clock fixtures private cars .....
Table reading fixtures private car.....
Lamps .....
Shades .....
Candelabras .....

"Fans."

Blow 9" .....
Blow 12" .....
Exhaust .....

"Miscellaneous Parts."

Switches all types .....
Door switches .....
Push buttons .....
Bells .....
Buzzers .....
Annunciator .....
Dry Batteries .....
Curling iron heaters .....
Flush receptacles No. 1508 .....
Telephone receptacles .....
Condulets for Baggage, Mail, Kitchens, etc. .....

"Labors."

Pipe fitters .....
Carpenters .....
Electricians .....
30 per cent added to estimated labor .....
10 per cent added to material .....

FORMULA FOR ENGINE LATHES.

Horse Power = Feed in inches X Depth of cut in inches X Inches cut per minute X No. cutting tools X Constant for material.

Constant for Material:—

Brass	.1
Cast Iron (Soft)	.3
Wrought Iron and Cast Iron (Hard)	.35
Mild Steel	.4
Medium Steel	.5
Tire Steel	.6

K.W. MOTOR INPUT FOR TURNTABLES.

69 Ft. Table—
Idle ..... 4.5 K.W.
Turning Engine Weighing approx. 300,000 lbs... 10. K.W.
Turning Engine Weighing approx. 266,000 lbs... 10.3 K.W.
80 Ft. Table—
Turning Engine Weighing approx. 210,000 lbs... 5.6 K.W.
Turning Engine Weighing approx. 300,000 lbs... 9.6 K.W.
100 Ft. Table:—
Turning Engine Weighing approx. 526,000 lbs. 32 to 24 K.W.
Time required to turn engines approx. one minute.

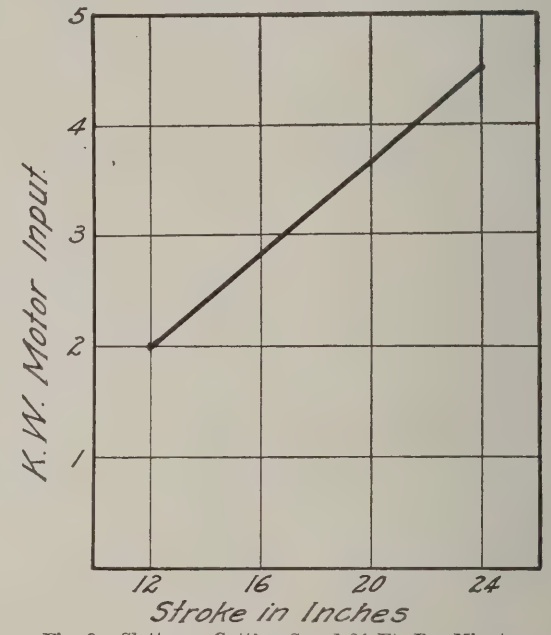


Fig. 9. Slotters. Cutting Speed 24 Ft. Per Minute.

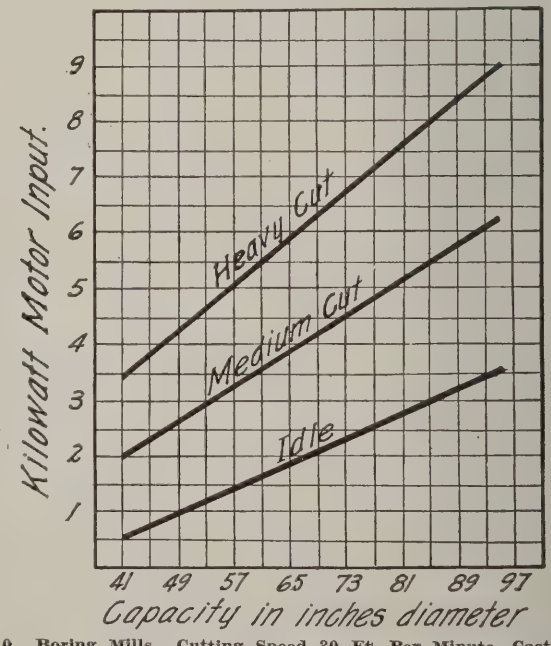


Fig. 10. Boring Mills. Cutting Speed 30 Ft. Per Minute, Cast Iron; 18 Ft. Per Minute, Steel.

Test of Hand Firing vs. Underfeed Stoker Firing on Horizontal Tubular Return Stationary Boilers.

	Stoker Fired.	Hand fired.
Time of Test	18 hours	12¾ hours.
Total coal fired	58351 pounds	32392 pounds.

Total ash and refuse...	6656 ponnds	3541 pounds.
Water fed to boilers...	460221 pounds	195315 pounds.
Water actually evaporated (corrected for moisture in steam)....	442733 pounds	191559 pounds.
Factor of evaporation..	1.1395	1.1061
Equivalent evaporation from and at 210°.....	504494 pounds	212036 pounds.
Average steam pressure.	105 pounds	110 pounds.
Average temperature of feed water.....	117° Fahr.	150° Fahr.
Average temperature of flue gases	448° Fahr.	580° Fahr.
Draft (inches of water)	.62 inches	.52 inches.
Percent moisture in steam	3.8 per ct.	1.9 per ct.
Number of boilers fired.	4 and 5	3
Average total boiler horse power developed.	808	482
Average horse power developed per boiler...	171	161
Builder's rating Horse Power per boiler.....	150	150
Horse Power rating per boiler at 12 sq. ft. water heating surface per horse power	125	125
Water apparently -evaporated per pound of coal as fired.....	7.88	6.03
Equivalent water evaporated from and at 212° per pound of coal as fired	8.65 pounds	6.55 pounds.
Equivalent water evaporated from and at 212° per pound of coal as fired corrected for difference in calorific value of coal used.....	7.88	
Net increase in efficiency due to Stokers.....	20 per ct.	

NOTE. Steam consumed by Stoker engine and operating mechanism not included.

Your Committee would again call attention to difficulty they had in determining subjects on which Data and Information is desired and we ask that for the help of the next Committee that such information be given them either by the Association or Executive Committee.

E. W. Jansen, Chairman.
J. C. Hensel.
H. G. Myers.
H. R. Bucks.

Report of the Committee on Improvements

Your committee has endeavored to make this report a complete review of all improvements made in electrical equipment during the past year of interest to the members of this Association.

Your committee has taken this up with all manufacturers in any way interested to the number of 235, writing them in some cases four letters, and supplimenting this letter campaign, the personal work of individual members of the committee.

We feel that the members of this Association will find this report of value as a reference volume when considering the design or installation of any new equipment, and hope it will be so used.

AXLE LIGHTING EQUIPMENT.

The Adams & Westlake Co. have redesigned their axle lighting equipment, and have incorporated in their new equipment many desirable features which the experience of the last 6 years has shown to be desirable. The generator is made considerably lighter and more compact. A new type of pole changer is provided which is of the cam type. There is no wear on the pole changer parts except when actually reversing generator connections.

The *United States Light and Heating Co.* report that they have re-designed their generator to take all standard makes of ball bearings and roller bearings without any alteration in the machine itself.

They are now furnishing the aluminum brush holders with all generators, as this metal lends itself readily for this work, lightens the brush mechanism and adds greatly to the appearance of the apparatus.

They have so modified the design of their combined brush rig and pole changer as to prevent installing the same in the generator in any but the correct position. The new brush mechanism will interchange perfectly with the older types.

They are now using case hardened steel bushings in the eyes of all suspension links, so as to reduce the amount of wear at this point and make it easy to restore the original size of the whole without destroying or losing the links.

They have also designed, and have put into service, a self-adjusting spherical tension spring seat. This accompanies all of their standard suspensions and has proved to be of great value in reducing the weight of the tension rods.

They have also provided all of their space bars with swivel guides which will eliminate all breakage of space bar guides near the locking nuts.

They have perfected a new generator regulator panel which is known as the Type S-1 panel. This panel has mounted upon it four pieces of apparatus, namely, the automatic switch, generator current regulator, generator potential regulator relay. The automatic switch is the standard construction which has proved so successful for the last fifteen years of service.

The generator current regulator is an independent piece of apparatus and performs but one function, that of regulating generator current. The generator potential regulator regulates the potential of the generator in such a manner that when the voltage of the generator shall have arisen to 42 volts, the relay operates and reduces the generator voltage to 35 volts, which is the floating voltage of 16 cells of battery. The potential regulator will hold the generator voltage at 35 volts regardless of load, and while the generator speed varies from the cutting-in point to the highest possible train speed. It is needless to say that maintaining the generator voltage as this regulator does at 35 volts, the battery current is reduced to zero, as 35 volts is the floating voltage. As the battery current is maintained at zero value by this regulator, it does not make any difference whether the battery circuit is open or closed. This regulator also has the property of enabling the gener-

ator to carry any lamp load that may be imposed upon the generator, whether circuit is open or closed.

They have also perfected a new lamp regulator which is not more than half the size of former lamp regulators. This regulator has been designed especially for use inside of railroad cars, or it may be put on a box and mounted outside in the customary manner. This lamp regulator is controlled by type K relay, which has been in successful operation during the past year, and which, as before stated, is mounted on the type S-1 panel.

They employ a system of air dash pot construction and have applied air dash pots wherever they are necessary on type S-1 panel and on type B-1 lamp regulator, thus eliminating the troubles that arise from the use of oil, glycerine and other materials in dash pots.

The *Gould Coupler Company* report a number of improvements in connection with their "Simplex" car lighting equipment.

They have brought out new panel type regulators for mounting in the car locker, which are known as type "BB" generator regulator and type "M" lamp regulator. These are arranged for mounting on an angle iron frame and connections between the panels are made with copper straps. They can also be mounted to suit the conditions of the car locker.

The type "BB" panel is very similar to their type "B" generator regulator, the automatic switch being identical. The type "M" panel is a combination of the type "B" lamp regulator generally mounted underneath the car, and the type "P" multiplier incorporating both on the same panel. The several devices are mounted on a slate base in such a manner to easily permit their removal from the front and it is never necessary under any circumstances to go to the back of the panels after once they are mounted in the car locker. All back connections are made with strap copper and each panel is backed up with cast iron grids into which are riveted all the studs whereon the front apparatus is set.

All adjustments on these regulators have been eliminated and after the set adjustments are once made and locked at their plant, it is never necessary to make any corrections. On the lamp regulator, they have adjustable running weights giving a range of about one volt above and below normal setting for voltage regulation. Both panels are standard throughout for all sizes of equipments with the exception of coil windings which are proportioned to suit the four different sizes of generators.

They have also developed a 1 K. W. machine, the construction of which is along the same lines as their present generators.

All generators are arranged for ball bearings or straight waste packed bearings.

A new type cable connection box has also been developed which greatly facilitates the removal of the truck without interfering with the connections between the the generator and the car wiring.

The *Safety Car Heating and Lighting Co.* report the construction of their new type "F" dynamo regulator and their new type "F" lamp regulator.

The dynamo regulator consists of two pieces of apparatus, the field regulator and the main switch. The main switch is of the closed magnetic circuit form with hinged armature carrying a heavy laminated copper contact, the whole being of the same design that is universally used for contractors for street railway work, and in circuit breakers and other switch apparatus.

The field regulator consists of two coils, a series coil carrying the total generator output, and a voltage coil, connected directly across the generator, and subject at all times to generator voltage. The plungers of these two coils acting through independent levers, vary the pressure in the field resistance carbons, giving the proper field current strength to regulate the generator output for all conditions of speed and battery charge. The voltage. coils prevent the voltage impressed on the battery rising above 40 volts, and the series coil prevents the total current given out by the generator rising above its desired output.

The type "F" regulator keeps the battery in approximately a floating condition, for if considerable current is used from the battery, then when the car starts the battery will take current up to the full capacity of the generator and be charged in the shortest possible time.

The accompanying cut shows the battery charge obtained with a type "F" regulator set for a maximum current of 65 amperes and a maximum voltage at the battery of 40. Two voltage curves are shown, one being the voltage at the battery terminals, and the other the voltage at the regulator board. The difference between these two curves at any point is the voltage drop in the battery leads.

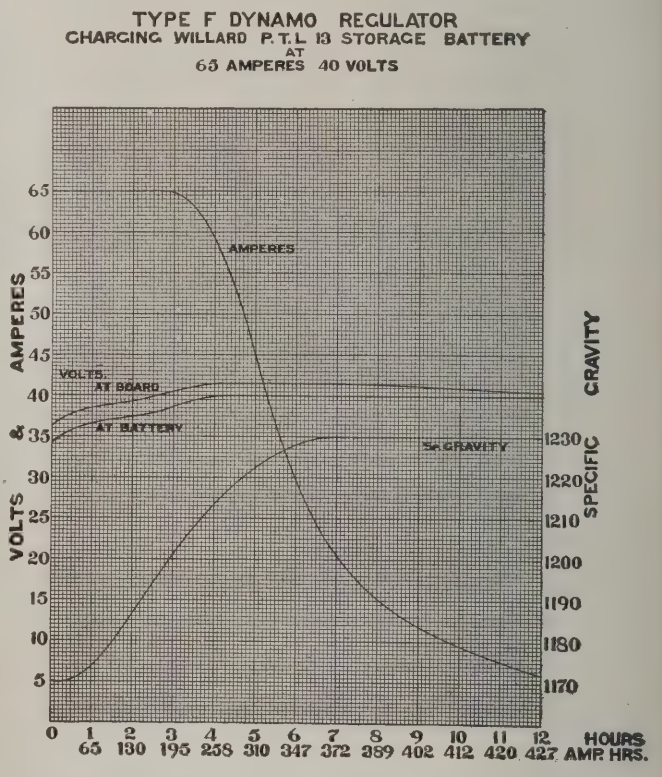


Fig. 1. Regulation Curve of Safety Type F. Equipment.

The type "F" lamp regulator consists of two carbon piles resistances connected in series with the lamps. The carbons are compressed by a coil spring, which is connected by a link, acting through a toggle mechanism to the armature of the actuating magnet.

The Safety generator is now equipped to accommodate any of the standard ball bearings. They report that a large number of generators have been in service with ball bearings for a sufficient length of time to assure them that their operation is going to be very satisfactory.

The Consolidated Ry. Elec. Ltg. & Equip. Co. have designed an entirely new generator suspension. The introduction of a new spring belt fastener described later under that head, has made it possible to mount the generator on a rigid support. The generator is mounted on two shoes which slide on two heavy bars and a take up screw is provided for loosening and tightening the belt.

Axle Pulleys.

The *Oneida Steel Pulley Company* have recently placed on the market their "Keystone" railroad pulley, the rim of which is considerably heavier than formerly, being 3/16" stock.

This company also furnishes with this "Keystone" pulley a corrugated steel bushing, which has the advantage of lightness, and on account of its flexibility insures a much better grip or fastening on the axle. This corrugated bushing is suitable for use on either tapered or straight axles. It is made in lengths longer than the hub of the pulley and fitted with malleable yokes or is simply fitted in the hub of the pulley without the extra yokes. The use of the bushing with the yokes permits lateral adjustment of the pulley on the bushing, which is in advantage in lining up the pulley with the generator.

The *American Pulley Company* of Philadelphia has designed and placed upon the market a new type of all steel bushing for clamping on standard tapered axles.

Aside from the general design which adapts itself to

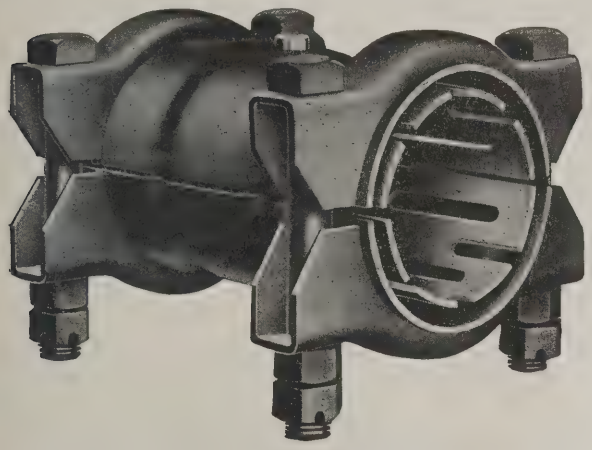


Fig. 2. American Malleable Steel Bushing.

small inequalities in the axle, the manufacturers make a particular point of the fact that there is no part of the bushing which is cast. The hub clamps or yokes are heavy pressed steel pieces, which cannot be broken, and the nuts are of the best grade of the cold punched castellated type. A cut of the bushing is shown herewith.

Belts.

The *Main Belting Company* of Philadelphia have, within the last year, placed on the market a new belt especially designed for railway car lighting service, known as the "Leviathan" belt. This belt is made of heavy stitched canvas, impregnated with a material which is not affected by water, and seems to have all the good properties of adhesion or traction necessary in car lighting service. Manufacturers claim that it will not be affected by either extremely hot or extremely cold weather. Manufacturers also state that the stretch has been so well eliminated from the belt during its manufacture that the normal generator take-up is sufficient to care for all belt stretch.

The *Victor-Balata & Textile Belting Co.* have recently placed on the market their new "Axonelat" car lighting belt, which is a modification and an improvement over the old Victor-Balata belt, so well known to car lighting men.

The foundation of "Axonelat" is 40 oz. duck of an especial weave, from which the excessive or undesirable stretch has been eliminated. While under tension the duck is impregnated with pure balata gum.

The edges are sewed with wax end threads and there are four rows of special stitching in the body, thus further reinforcing the belt.

As an additional protection there is an extra cover on the pulley side to act as a cushion and also to keep the cinders, that lodge between the surface of the belt and the pulleys, from imbedding themselves in the body of the belt, thus causing frictional heat and abrasion.

The *Morse Chain Company* advise that they have made an improvement in their chain drive for axle equipment in providing a special chilled sprocket wheel for both dynamo and axle. They also state that nickel, chrone, vanadium stock is now used in the rocker joint chains.

Belt Fasteners.

The *Crescent Belt Fastener Company* of New York report that the points of their rivets have been sharpened to permit of their easier penetration of the belt, and "Crescent" plates have been curved at the edges to allow of a freer movement of the belt as it leaves the pulley.

The Alligator" fastener, made by the *Flexible Steel Lacing Company* of Chicago, has recently been introduced

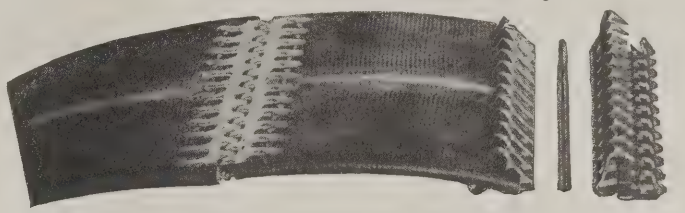


Fig. 3. Flexible Steel Lacing.

for railway car lighting belt service and that company reports a recent improvement in the fastener in that the hinge pin is made up of two sections having oval surfaces which rock against each other and largely eliminate wear at this point.

The *Consolidated Railway Electric Lighting and Equipment Co.* report the design of a new spring belt fastener. The joint is made in a V shape and seven small sturdy springs are riveted across the joint on the top side of the belt. When full tension is applied these springs allow the joint to open up for ¼ to ⅜ of an inch.

Ampere-Hour Meters.

The *Sangamo Electric Company* report a marked improvement in their ampere-hour meters, which particularly adapts this meter for use in axle lighting service. This meter is described fully in another part of this issue. It is called the "Variable Resistor" type. There is a magnetically operated element in series with the mercury chamber and this introduces a resistance when the current flows in a charging direction, thus causing the meter to register 25 to 30 per cent. slower on charge than on discharge, as desired. The company reports that this feature can be applied in any capacity of shunted meter, the lowest capacity being the 15 ampere meter.

By providing a cut-out contact at the zero position the meter may be employed to automatically control the operation of any axle equipment on an ampere-hour basis. This improvement is fundamental in its nature and should be of special interest to all car lighting men and manufacturers. The Sangamo Company also reports that they have improved the details of the standard ampere-hour motor—the simple and the differential shunted types.

They also state that they are about to place on the market a small and comparatively inexpensive type of ampere-hour meter designed especially for use on storage battery baggage trucks.

Ball Bearings.

As ball bearings have just recently been applied in railway car lighting service, we will endeavor to give here a brief description of some of the more important types of ball and roller bearings whether they involve any rad-

ical improvement within the last year or not. It is considered that the subject is of sufficient interest to warrant this.

The railway type "Hess-Bright" ball bearing consists of two race-ways, an inner and an outer, the inner one being fastened to the armature shaft and the outer one resting in the generator frame head. These race-ways are simply concentric rings, made from the finest alloy steel, hand forged and oil tempered, and finally ground and polished within limits of a few ten-thousandths of an inch. Between these two, the balls roll. The bearing is not full of balls, because the grooves in which they roll prevent the insertion of a complete circle; the spacing of the balls is maintained, and rigidity imparted to the entire element by a heavy manganese bronze separator in two halves, riveted together.

The size of bearing adopted by the ball bearing committee of the association is No. 412, and in this size of the bearing the balls are 1-1/16" in diameter. The crushing load of each of them is about 90,000 pounds.

Two bearings are used in each generator, the one on the commutator end taking all the thrust, the deep grooves of the railway type bearing make it desirable for this purpose.

The "Norma" bearing, designed for railway car lighting work, consists of a combination roller bearing with a small ball bearing to take the end thrust. The highest accuracy is maintained in both roller and ball bearings, in fact this company has developed a very complete line of measuring instruments of extremely high accuracy for measuring both the diameter of balls, rollers and the interior diameter of the race-ways. An accuracy of one-ten-thousandth of an inch can be measused by these instruments, according to statements by the manufacturers. These are imported by the *Norma Company* of New York City.

The S. K. F. ball bearing is also an imported bearing of high accuracy and provides for automatic and instantaneous self-alignment with the bearing itself. A unique retainer is provided with this bearing. It is punched and pressed from a single piece of Swedish steel, made and treated specifically to meet ball bearing requirements. This type of retainer has but little weight and small contact area against the balls. It seems to combine simplicity with strength and reliability. This bearing is imported by the *S. K. F. all Bearing Company* of New York City.

The *Railway Roller Bearing Company* of Syracuse, N. Y., state that their roller bearing has been used extensively in connection with cars of the Third Avenue Railway Co. of New York City. The main bearing consists of a roller bearing of a size determined by the surface to which it is applied and there is an auxiliary ball bearing, in severe cases a double bearing, to take up the end thrust. Manufacturers state that experience in the Manhattan Elevated train service has shown that 1½ pounds of non-fluid oil placed in each bearing at intervals of six months affords ample lubrication.

Generator Connectors.

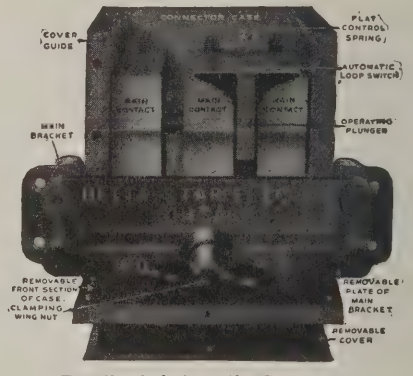
The *Delta-Star Electric Company* of Chicago report the manufacture of a new connector designed for use in connecting axle generators to the wiring on the car body. When a generator truck is removed from a car the cables are disconnected by simply pulling the plug attached to the generator cables from the receptable mounted on the under side of the car. The special locking hook prevents the plug from jarring out even though the clamping screw should become loosened by vibration.

HEAD END SYSTEM.

The *Westinghouse Machine Company* reports the introduction of a new train lighting turbine set. One of the main features of the turbine is that the steam, after expansion in the nozzle and passing through the turbine wheel, is returned into a reversing chamber and re-directed on the blades. This permits of absorbing a large percentage of the available velocity energy of the steam without employing unduly high rotative speeds. The dimensions of the set are as follows:

Length	5′ 9″
Width	2′ 8″
Height	3′ 3″
Weight, complete	3300 lbs.

Side View of Connector Showing Slide Cover.



Detail of Automatic Connector.

TRAIN CONNECTORS.

The *Delta Star Electric Company* of Chicago advise that they are now manufacturing a new vertical type automatic train lighting connector, the leads for which are brought out at the side or end, as may be best suited to car construction, and by using the proper type it is only necessary to cut three round holes in the car. The cables then run directly into the connector, rendering unnecessary any cutting for the connector and eliminating the usual protecting cover for the leads.

The *Conlan Electric Company* of New York advise that they are now manufacturing a water tight charging plug and receptacle. A valve automatically closes the opening into the receptacle when the charging plug is withdrawn. A rubber gasket, carried by the plug, presses against the face of the receptacle when the plug is inserted, making a water tight joint. The company states that their receptacle is water tight both on charge and discharge and that it has been adopted by the United States Government for use on battleships and steamships.

STORAGE BATTERIES.

The *Edison Storage Battery Company* state that the improvements made by them during the last year include a new type suspension or arrangement of cells in the trays such that a dead air space of 2½" is provided between the bottom of the cells and the bottom of the trays, eliminating grounds at this point, etc. They have also increased the contact area at points where the plates are secured to the cross bar and have also increased the size of the pole or binding post, reducing the resistance of contracts to a very low value. Connectors between cells are now furnished having a conductivity equal to No. 00. The flexible rubber covered cable used for tray connectors has been increased to No. 0 copper.

The *Electric Storage Battery Company* report that while there has not been any radical changes in their batteries for car lighting purposes during the past year, there has been a gradual development of the plates best suited for this service.

The Manchester positive with a Plante Permanized negative is recommended for car lighting service.

The *Geiszler Storage Battery Company* of New York City state that they have developed a lead sulphuric acid type of battery, which does not become sulphated or injured on being left without re-charging for any length of time, in either a charged or discharged condition. At the present time they are not in a position to supply these in the capacity used for railway car lighting service, but expect to do so shortly.

CAR LIGHTING LAMPS AND FIXTURES.

Lamps.

The various incandescent lamp manufacturers report that carbon and tantalum lamps have to a great extent been replaced by mazda and gem lamps, the greater majority being the former. This has been due to the development of these lamps to meet the general operating requirements in all fields. The Mazda lamp is now manufactured entirely in the drawn wire filament, which has established itself in ruggedness and durability. A number of new sizes and types of Mazda lamps have been brought out within the past year, which include the 10-watt train lighting lamp, operating at 1.25 watts per candle, enclosed in a G-18½ bulb, the 10-watt 100 to 130 volt sign lamp, the 15 and 20-watt regular, 100 to 130 volts in the S-17 bulb and the 25-Watt, 220 volt 1.35 watt per candle in S-19 bulb.

The efficiency of Mazda lamps on the whole has been raised approximately 7 per cent. The higher wattage lamps now have an efficiency of 1 watt and 1.1 watts per candle. There has also been a reduction in price of approximately 40 per cent. during the past year.

The *Heany Lamp Company* state that they are undergoing a re-organization and that the name of the new outfit will be The Independent Lamp and Wire Co. of New York City.

Fixtures.

The *Safety Car Heating and Lighting Company* reports that the wide application of the "Safety" shade holder for supporting shades and globes on lighting fixtures in railways cars has called for some additional types of this particular holder to accommodate various types of reflectors and new developments in lighting fixtures. The problem of maintaining a reflector in a fixed position in relation to the electric lamp filament, has been met by a modification of the "Safety" shade holder, wherein a wide latitude in lamp and reflector relations is to be had. They have also developed a complete line of condulet fixtures for baggage and mail cars, wherein the "Safety" shade holder is employed. They have also adapted the "Safety" shade holder to the Pintsch mantle lamp, increasing the efficiency in these fixtures by providing a quick method of removing and replacing reflectors and shades.

This company has, during the past year, developed several types of indirect lighting fixtures for railway service. The first indirect lighting fixture made by this company used an art glass bowl, of such a density as to provide a soft illumination of the color design of the bowl. Mounted at regular intervals inside a bronze band twelve porcelain receptacles were used with twelve tungsten lamps. The lamps were held in a horizontal position so that the maximum light was concentrated on the ceiling, directly and by reflection. The reflector used consisted of a polished nickel band running underneath the lamps and of sufficient width to intercept the maximum flux of light. The tip candle power of a tungsten lamp is very small, but enough to throw sufficient light across the bowl to illuminate that portion of the bowl directly opposite from the lamp.

They have also developed indirect lighting fixtures wherein the bowl of the fixture was metal, having a perforated design, backed by art glass.

One of the most practical advancements made during the past year in lighting fixtures are the reflector-bowl-envelope units developed by this company. These fixtures give a high state of illuminating efficiency, completely shield the eye from the source of light, and protect the reflector and bowl from dirt. This type of unit has been developed for both electricity and Pintsch gas.

The construction of this type of fixture is one in which a prismatic reflector and bowl is used, the prismatic bowl being surrounded by an opal envelope.

They have also developed a successful method of electric ignition for the Pintsch mantle lamp, and have entric ignition for the Pintsch mantle lamp, and have embodied this principle in several types of fixtures. For coaches or cars having a simple layout of lamps, a magneto is used for generating the igniting spark, and it is only necessary for the attendant to turn on the gas at the main cock and turn the magneto handle to light the lamps.

The *Benjamin Electric Company* state that they have perfected a new car lighting ceiling fixture supplied with a two-part porcelain socket with lamp grip, this fixture being adapted to firmly clamp the reflector with the ordinary 2¼" fitter by means of 3 springs and a cam clamping device, locked in its clamped position by a bolt.

They have also developed two forms of sockets with lamp grip for car lighting, one of which is adapted to attach to outlet box; the other in the form of a two-piece wall socket which can be supplied with brass covers.

Pass & Seymour, Co., have now a full brass line of "Shurlock" locking sockets and receptacles. The "Shurlock" prevents theft of lamps and reflectors, also prevents lamps working loose from vibration.

Shades and Reflectors.

The *Nelite Works of General Electric Co.,* formerly the Holophane Co., has continued on a large scale the development of reflectors and lighting accessories for car lighting, begun last year, and reported upon by your Committee. The new developments in car lighting units include the following.

A prismatic reflector, No. 18221, with 2¼" neck for day coach lighting with 50 watt lamp from center deck.

A prismatic reflector, No. 18321, with 4¼" neck for day coach lighting from half deck, with 15 watt or 25 watt lamp.

A heavy density opal reflector (of the glass known as White Iris), No. 18226, for day coach lighting with 50 watt lamp from the center deck. This reflector has a 2¼" neck.

A heavy density opal reflector (of the glass known as White Iris), No. 18621, for day coach lighting from the half deck, with 15 watt or 25 watt lamp. This reflector has a 2¼" neck.

A medium density opal reflector (of the glass known as Pyro), No. 18746, for day coach lighting from the center deck, with 50 watt lamp. This reflector has a 4½" neck.

The development, in co-operation with the Safety Car Heating and Lighting Company, of a reflector-bowl-envelope type of unit, for lighting of parlor cars, dining cars, etc., with 50 watt or 75 watt lamp from the center deck. The reflector and bowl of this unit bear the catalog number 18312. This type of unit has the highest illuminating efficiency of any enclosing unit yet designed. The employment of an envelope greatly decreases the necessity for maintenance attention in order to maintain the glassware in a suitably clean condition, while at the same time it adds to the artistic appearance of the unit as a whole.

The development, in co-operation with the Safety Car Heating and Lighting Company, of a reflector-bowl-envelope type of unit, for the Pintsch mantle lamp. This unit closely follows the general construction of the electric unit referred to above and possesses all the excellent features of that unit.

Two aluminumized metal reflectors for postal car lighting with Pintsch mantle lamp. One of these, No. 18418, is designed as the main unit to be located down the center of the postal car. The other, No. 18490, is designed for lighting the letter cases.

Two porcelain enameled reflectors for postal car lighting with Pintsch mantle lamp. One of these, No. 18417, is designed as the main unit for lighting car down the center deck. The other, No. 469, is designed for lighting letter cases.

An enameled metal reflector, No. 18441, for baggage car lighting with a 15 or 25 watt lamp.

An enameled metal reflector, No. 18441, for gagge car lighting with a 15 or 25 watt lamp.

A hexagonal reflector bowl unit for buffet or library car lighting. The reflector and bowl of this unit bear the combination number 18386. The unit is designed for use with a 50 watt lamp, and is intended to be used as a half deck unit. It is claimed by manufacturers that this is the first unit placed on the market which represents a fully adequate engineering and practical study of library car lighting.

A vestibule lighting unit, No. 18415, designed for passenger car vestibule lighting with 15 watt or 25 watt lamp. This unit consists of a porcelain enameled metal reeflctor, equipped with a weather-proof socket of standard construction and especially chosen with regard to the severe requirements of the service. The unit is intended to be set up into the vstibule deck, preferably on either side of the door, the bottom of the unit coming flush with the under surface of the deck.

The Holophane-D'Olier Line of metal reflectors has undergone a tremendous development within the past year. The aluminumized reflectors of this line are furnished in two types, the well-known Extensive and Intensive. The porcelain enameled reflectors are furnished in two types, —the deep bowl and the shallow dome reflectors. Both aluminumized and enameled reflectors are furnished with a large variety of holders to fit all conditions of service. These various holders include the clip spring holder, the type of holder with which Holophane-D'Olier reflectors were originally equipped; the clamp strap holder, a clip spring type which locks to the socket, preventing all danger of the reflector working loose; standard 2¼" heel for use with separable holder; the porcelain socket holder, a type which permits the use of reflectors with ordinary weather-proof sockets; the solid extension, a one-piece reflector and holder proposition, the holder attaching rigidly to a ⅜" pipe suspension, or being furnished with cord bushing for drop-cord work; and finally, the threaded extension, an extension possessing all the desirable features of the solid-piece reflector socket type, but permitting the easy removal of the reflector from its socket holder, and the substitution of another size of reflector, whenever such a change is desired.

All of the above types of holder are offered in combination with any of the aluminumized or porcelain enabled metal reflectors. This offers a combination of four (4) types of distributions with six (6) types of holders in five (5) sizes. In short, the customer has the choice of 120 standard metal reflectors, from which to meet all requirements as to lamp size, method of mounting and type of distribution. It is believed these will meet every demand for practical lighting, and most demands for special lighting with metal reflectors.

The *Jefferson Glass Co.* state that they have designed a new Doric line of shades, as shown herewith, the main idea in their design being that they have no grouves or indentations to catch and hold the dirt. The shade is at the same time of a very effective, classic design.

The *Haskins Glass Co.* report that it has improved its "Lucida" line of reflectors for car lighting by decreasing their weight fully 20 per cent, this being accomplished by pressing the reflectors thinner, thereby allowing more light to be transmitted, and consequently increasing their total efficiency, though the diffusing qualities and ruggedness of the reflectors have not been interfered with.

New and unique designs in elaborately decorated shallow bowls in "Lucida" glass for railway car center deck lighting are now being brought out. Also, pendants of new and varied shapes with etched designs.

The *Macbeth-Evans Glass Co.* report that an improved chemical composition of Alba glass has caused a so-called softening of the texture of the glass leading to more

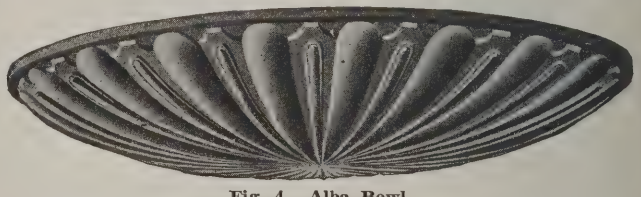


Fig. 4. Alba Bowl.

pleasing appearance and better diffusing powers and ultimately resulting in lighter weight shades and globes.

An improved heating treatment has led to a still further improvement in appearance and gives much higher values of reflection from shades so treated. The advantageous result coming from lighter weight pieces of Alba glass of lower absorption has favored the development of shallow bowls that are particularly suited for flat fixtures in the center decks; or plaques, both round and oval, for bulkheads.

For coach lighting the best type of Alba shade recently made is the deep bowl shaped No. 3429. This for center deck lighting with 50 watt G 30 lamp used in the ¾" position gives excellent optical protection from bare filament. With the usual 5 ft. spacing this combination of lamp and shade furnishes close to 4 foot candles average illumination or over 40 per cent useful lumens. Where bowl frosted or enameled lamps in the G-18½ bulb are satisfactory the new distibuting Alba shade No. 3417 has been developed.

The requisites of higher efficiency, commercially inexpensive and non-glaring or non-tiring reflectors have been followed to culmination in a new type of opal shade of Alada glass distinctly different, being of a glass free from the yellowish tint of the oldtime opal. These shades are

Fig. 5. New Deep Bowl Alba Shade.

given a fine satin finishing interior treatment that prevents direct reflection from the filament but is not so rough as to catch dirt. They are especially well adapted for use in postal cars and baggage cars.

FANS.

The *General Electric Co.* has developed a new fan of very attractive lines and with several improved points of design for railway service. The unique feature of the fan is the baseplate, which is provided with spring contacts and is mounted on the car participations. The motor base has pins which hook over the large screws on

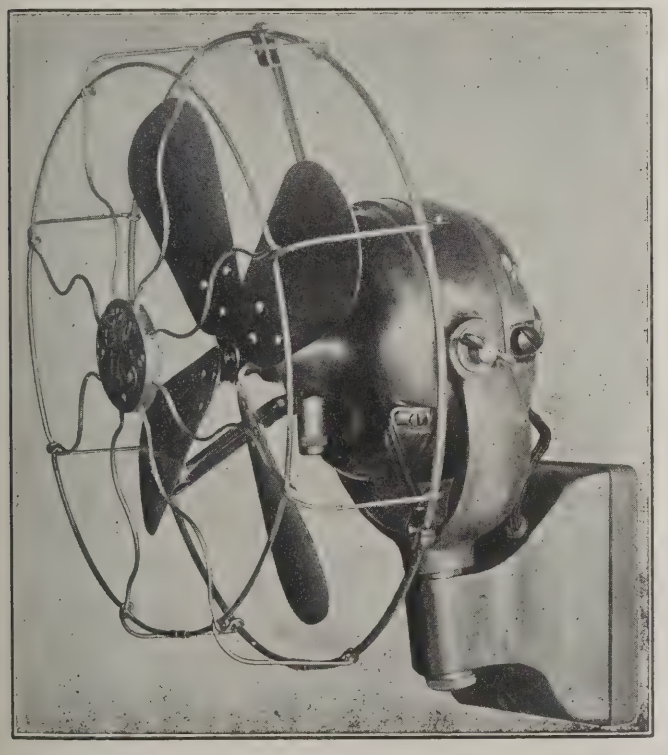


Fig. 6. New G. E. Railway Car Fan.

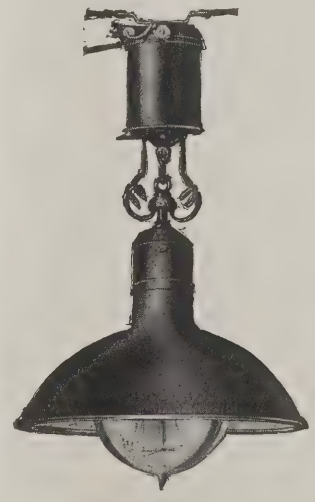
the baseplate, allowing the motor to be removed readily from the wall without taking out the screws or marring the car finish. Contact plates on the motor base make contact with the springs on the plate, so that the removal of the motor does not disturb the wiring connections. The plate remains on the partition the year around, and in the fall when the fan is taken down a neat cover fits over the plate. The bases and baseplates are interchangeable.

The motors are totally enclosed and dust proof. They can be wound for double voltage operation, which is accomplished by the opening and closing of a single contact that not only changes the motor winding but at the same time alters the value of the control resistance.

By means of a special friction arrangement in the motor base and through the yoke connections, the fan is provided with both horizontal and vertical adjustment. Easy accessibility to the commutator and motor interior is secured through a drop cover at the back of the motor. The two brushes and brush holders are readily taken out by loosening a screw in each case. The fan hub is fitted with oil slings, whereby all oil working out on the shaft is thrown back to the oil wells. The armature and commutator are mounted on a brass sleeve and the shaft is of tool steel. Fans are finished with any special finish to suit requirements.

The *Westinghouse Electric & Manufacturing Co.* advise they are now making fans with drawn steel frames.. They state that this fan is of very high efficiency, light weight, and is of a very pleasing design. The new mechanism for oscillating these fans is totally enclosed and works in a lubricant. The fan can be changed from the oscillating type to the stationery type while in operation, and vice versa, and a clutch is provided which allows the blades to revolve if the oscillation is interfered with.

Thompson Electric Co., Cleveland, has developed a new cut-out lamp hanger which makes it possible to lower any arc lamp or tungsten unit right down to the ground from any height. When lowering, the lighting unit is entirely cut-out of circuit and in both locking and unlocking hanger there is no jar or jerking which might injure tungsten filament.



Lamp in Position.

Hanger Casing Removed and Lamp Lowered.

SHOP AND YARD LIGHTING.

The *Cooper-Hewitt Electric Co.* have during the past year, perfected the manufacture of their quartz tube mercury vapor lamp and it is now offered for railroad service. The light given by this lamp is considerably more yellow then the original mercury vapor lamp. It is offered in units of 1000 m. l. h. c. p. candle power, 110 volts, 4 amperes, and 2700 m. l. h. c. p. 220 volts, 3.5 amperes. A magnetic device is supplied for automatically tipping the tube so as to strike the arc when the lamp is turned out. The manufacturers state that the life of these tubes is from 2000 to 4000 hours.

The *Benjamin Electric Co.* state that they have perfetced a new lamp and grip, which will be embodied in their reflector sockets, supplied for shop, train-shed, plat-

form and yard lighting. This same gripping device will also be employed in sockets furnished for car lighting.

They have also added a line of wire lock guards for single lamps and clusters. These guards may be employed

Fig. 7. Benjamin Lamp Grip.

without locks, but are arranged so that a small size padlock may be used.

The *Wheeler Reflector Company* has developed two styles of Reflectors of special interest to the railway trade.

1st. The WER type, which consists of a Porcelain Enameled Steel Canopy for a socket housing with a threaded copper screw ring. The Reflector part of the unit has a threaded collar which screws into the screw ring of the canopy. This allows the Reflector to be easily removed from the canopy for cleaning.

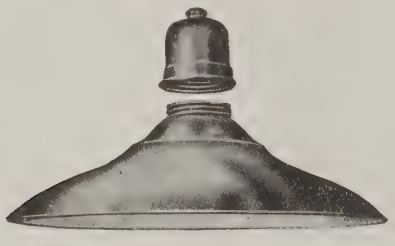


Fig. 8. Wheeler Screw Type Reflector.

2nd. The NEK type. This is a Parabolic Angle Reflector specially suited for roundhouse lighting. This is made for all sizes of lamps up to 500-watts.

MOTORS AND POWER EQUIPMENT.

Motors.

The *Burke Electric Co.*, of Erie, Pa., have designed a new speed change device, which is essentially a very compact combination of the cone pulley and back gear principle. Provision is made whereby the belt on the cone pulleys may be tightened to prevent slipping when running at slow speeds. This device is taken up more fully by the Committee on Shop Practice.

The *Garwood Electric Co.*, of Garwood, N. J., advise that they have made improvements in both the mechanical and electrical design of their reversing planer motor, to meet the severe requirements of this service.

The *Westinghouse Elec. & Mfg. Co.* state that they have developed the reversing motor equipment for machines such as planers, shapers, slotters, gear cutters, etc. A special controller, which is automatically operated by the movements of the driven machine itself, has been designed for use in connection with this motor. The motor is directly connected to the machine without belts, pulleys or countershafts. The motor is of the adjustable speed, commutating-pole type, strongly built, semi-enclosed and especially suited for the work. The armature is relatively long and of small diameter, making the inertia low, as required for quick reversing. The speed adjustment is entirely by field control, and the commutatoin is good at all adjustments and loads within the motor capacity.

This equipment is operating in several railway shops. When substituted for belt drive on old planers, the output of the planers has been materially increased, and the expense of operation reduced. The introduction of these equipments throughout their shops is being seriously considered by several railroad and steel companies.

The panel starter (type S) affords a very compact device for starting and protecting motors up to and including 60 HP., 115 volts, 125 HP., 230 volts, and 250 HP., 550 volts. On the front of a single panel is a line switch, shunt magnet switch for closing and opening the main circuit, an overload relay and a single pole, multi-point knife switch for cutting out starting resistance in steps. The magnet switch opens promptly on failure of voltage or on overloads.

Overload and no-voltage release features, as well as a dynamic braking feature, are now available for use with Westinghouse machine tool controllers. The need of these features has been strongly emphasized by railway electrical engineers, who will accordingly appreciate their development.

The *Fairbanks-Morse Co.* state that in manufacturing their induction motors they now fuse the ends of the rotor bars to the end rings of the armature instead of employing a clamped or soldered joint as formerly. This makes a joint which is perfect electrically and exceedingly strong mechanically and at the same is free from oxidization.

ELECTRIC TRACTION.

The *General Electric Co.* report many changes of existing electric railway plants from 600 to 1200 volts. They also state that work is now in progress on the contract taken for the electrification of the Butte, Anaconda & Pacific Ry., between Butte and Anaconda, Mont., for operation on 2400 volts direct current. This is a distinct advance over previous practice; for it represents the first railway electrification for operation on as high a voltage as 2400 volt direct current in this country, and is, moreover, one of the largest installations of electrical equipment on a road formerly operated by steam.

Fig. 9. Electric Locomotive.

Seventeen 2400 volt direct current locomotives of the articulated truck type, each weighing 75 tons, are included in the equipment. Fifteen of these are for freight and two for passenger service. Each locomotive will be equipped with four GE-229, 1200 volt, commutating pole, twin geared motors, insulated for operation two in series on 2400 volts. Control of the motors will be effected through special Sprague-General Electric Type M con-

trol equipments, a dynamotor being used to furnish 600 volts for the operation of the contactors, also the lights and air compressor. The dynamotor will have two windings, 1800 and 600 volts, and will be direct connected to a blower for ventilating the motors.

Flexibility is to be the essential characteristic of the overhead conductor system in connection with the 2400 volt electrification on the Butte, Anaconda & Pacific Ry. A special type of flexible catenary trolley suspension will be employed over some of the sidings and smelter tracks. Single 4/0 copper trolley wire is to be used throughout; and single ½ in. galvanized steel messenger cable will be strung for the catenary suspension, which will be supported every 150 feet by side brackets on the main line and by cross span construction in the yards.

The gas-electric car of the *General Electric Co.* represents a recent development of a self-propelled unit for railways; for a flexibility of operation is obtained through the direct application of electric power for motive drive that results in a safe, reliable, convenient and economical means of transportation. A smooth and rapid acceleration of the car is obtained without rheostatic power losses or gear changes by varying the strength of the generator field. This is an essential improvement introduced by the gas-electric car.

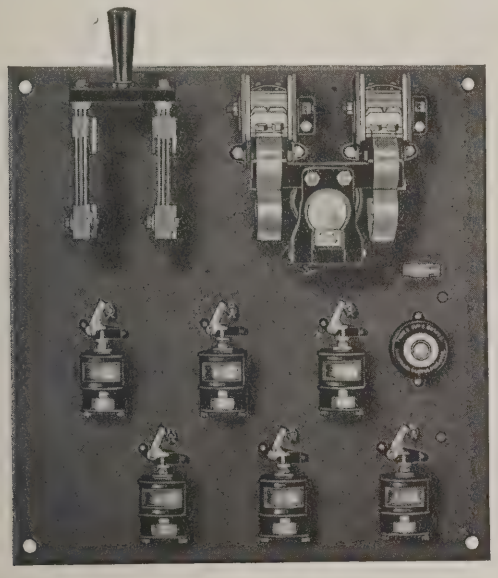


Fig. 10. Starting Panel.

Controllers.

The *Electric Controller & Mfg. Co.* of Cleveland, report developments and improvements in their controllers and starters for motors, in sizes up to and including 200 H. P. A single contractor, which is operated by a coil in series with the motor circuit, is employed. This is locked in the open position when the motor current is in excess of a certain value, but closes when the current, due to acceleration of the motor, drops to the value at which the switch is adjusted. The closing of a number of these switches cuts out progressively portions of the starting resistance, providing maximum acceleration without excessive current. With this type of automatic starter it is only necessary to close the line switch to start the motor and open the switch to stop it.

An automatic controller for machine tools is furnished, which not only limits the current values at all times but may also be used for reversing the motor, stopping it by dynamic braking and starting in the reverse direction. The same limitations of current flow are maintained.

They also state that they are using a resistance wire of no temperature co-efficient in all of their motor field rheostats.

Fuses.

The *A. F. Daum Co. of Pittsburg,* have made several improvements in refillable fuse shells. The knife blade types formerly made with washer contacts and the terminals screwed on the tubing, are now made with brass bars lain across the ends of the tubing, clamping the ends of fusible element tightly against inside of terminals by means of screws on the outside, the terminals slip over the ends of tubing and clamp on. Blades are easily aligned. Type B ferrule contacts are greatly improved with different contact arrangements to meet the different working conditions. This company has also perfected a simple refillable fuse plug of standard size and shape.

The *Economy Fuse & Mfg. Co.,* Chicago, during the past year have added several sizes of fuses to their line. The makers now guarantee the rating and performance to be in strict accordance with the specifications of the National Board of Fire Underwriters, although the product is not officially approved by the National Board at this time.

A venting arrangement has been provided which permits the escape of gases through an angular and circular path without the possibility of external venting of fire.

Instruments.

The *American Ever Ready Co.* state that they now provide their eelctric flash lights with a permanent contact so that they may snap closed while lit.

The *Westinghouse Electric & Mfg. Co.* state that they now manufacture meters of the D'Arsonval principle, with the single air gap construction. Two permanent magnets are now clamped together before being magnetized and edged, and this results in the minimum weakening of magnets in service, a stronger magnetic field, which results in a high torque meter. The moving element can be taken out by merely removing the upper bridge.

The *Weston Electrical Instrument Co.* state that they have just placed on the market a new line of small instruments for portable and switchboard service. These can easily be carried in the pocket yet are of high accuracy and of sturdy construction.

The *Roller-Smith Co.* state that all switchboard and portable D. C. instruments are provided with the resilient jewel mounting, which protects the jewel and pivot against rough usage.

They have also developed a new line of inexpensive horizontal edgewise A. C. switchboard instruments.

They also state that their new shunted astatic D. C. watthour meters are furnished in capacities up to 20,000 amperes.

L. M. Pignolet Co., of New York City, state that they are now making a new line of compact volt meters, ammeters and volt-ammeters. They provide an easy means for correcting the zero or other errors arising from rough handling. Instruments are of a handy pocket size and inexpensive.

J. G. Biddle Co. of Philaedlphia, state that they have developed a new line of Megger testing sets, which makes it possible to measure resistance within wide limits direct, just as current is measured by an ammeter. A small D. C. hand dynamo in the same case furnishes current so that no outside source of energy is required. For measuring low resistances the bridge Megger is found to be more convenient than the usual Wheatstone bridge.

Foote, Pierson & Co. of New York City, have developed a new small portable photometer for use in car lighting work. This employs a small standard lamp, storage or dry battery for which can be carried in the pocket. The dimensions of this are 2½ x 3½ x 5".

They also state that they have just brought out the Weaver portable testing set for railway block signals, which consists of a special Weston volt ammeter with necessary shunt, two slide wire rheostats arranged to work separately, series or parallel, and a volt-ammeter indicating switch. The instrument is encased in a leather carrying bag.

The Hoskins Mfg. Co. of Detroit, who have taken over the manufacture of International meters, state that these meters are now made with a one-piece pole shoe construction, which makes the meter more robust.

They also employ the unit support of moving parts, which permits of all moving parts being easily removed.

They also have developed a resilient pivot mounting for their bearing, which makes their portable meters capable of standing severe jars without impairing their accuracy.

Resistance Units.

The *Ward-Leonard Co.* of Bronxville, N. Y., state that they are now making their enameled resistance units of a zero temperature co-efficient. These are wound on the pottery tube and the whole unit covered with a baked enamel. They furnish these units with ferrule ends so that they can be mounted on fuse clips where desired. They state that they have developed their process so that they can now furnish resistance as high as 10,000 ohms upon a unit 7/16" in diameter and 8" long.

Lighting Arresters.

The *Westinghouse Electric & Mfg. Co.* state that they have developed a new type "B' arrester for pole mounting on 1500 volt D. C. circuit. This is of the magnetic blow-out type with the usual circuit, but when the lower half is let down the line circuit to arrester is opened and the active parts are dead, thus permitting safe inspection and repair.

They have also developed the electroletic arrester and now offer it for either 600 or 1500-volt circuits. The units consist of three standard A. C. aluminum trays for 600-volt service and seven for 1500-volt service. The space between trays is filled with oil for insulation and heat conducting purposes. The whole is encased in a substantial iron tank.

Circuit Brakers.

The Roller-Smith Co. state that in their new industrial type breakers copper parts are not finished. This in an inexpensive, sturdy breaker, but of sufficient accuracy for most industrial work.

The *Westinghouse Electric & Mfg. Co.* advise that their line of "C. A." breakers have been practically redesigned in the last year. They are now available in all capacities from 1,200 amperes up to 14,000 amperes. The carbon arcing contacts are now copper plated on the backs and sides to as to make a very low resistance contact at this point. This results in a larger portion of current being actually broken by the carbons instead of the secondary and tertiary copper contact.

High Tension Switches.

The general tendency toward the employment of high voltages in connection with railroad service has developed a demand for both indoor and weatherproof high voltage disconnecting or sectionalizing switches and fuses.

To meet these requirements the *Delta-Star Electric Co.* of Chicago, has developed and standardized a complete line from 1,100 to 110,000 volts. All the high voltage switches are equipped with automatic locking blades preventing accidental opening.

The *Standard Underground Cable Co.* has brought out several new high tension junction boxes, which facilitate interconnection of multi-conductor cables. These boxes make it possible to bring the multi-conductor cables into the junction boxes without separating them into single conductor cables.

ELECTRIC HEADLIGHTS.

The manufacturers of the Pyle-National headlight state that they have recently placed on the market what is known as the type "E" equipment. The arc lamp, armature, brush holders and ball bearings are the same as employed in the old-style equipment. The principal feature of the turbine is steam economy. The manufacturer states that this turbine operates on 160 pounds of steam per E. H. P. per hour. The entire equipment has been simplified as much as possible to minimize upkeep and repair.

The *Remy Electric Co.*, who recently took over the manufacturing interests of the R. G. Peters Headlight and the American Headlight, report that their turbine wheel has been strengthened and their bucket and nozzle design modified to give greater steam economy. The diameter of the generator end of the shaft has been increased and the main bearing bushing re-designed to eliminate oil throwing. Both diameter and length of the commutator have been increased and the generator end bracket is made much stronger and has been re-designed to allow plenty of room to get at the commutator.

A larger ball bearing is now used on the dynamo and bracket. The top and bottom brush holders are made interchangeable and the size of the brushes increased. Governor parts are now made of malleable iron instead of brass. A new lower electrode holder has been designed for the arc lamp.

The Esterline Co., of Lafayette, Indiana, have developed a graphic meter for recording the output of motor drive of various machine tools.

Their graphic volt meter may be used for checking up the performance of any car lighting system on the road.

They have also developed a magnetic type generator which when driven from the axle may be used to indicate a continuous record of train speed.

They have also developed an axle generator outfit for locomotives which is driven by a flexible drive and with a storage battery auxiliary supplies current for the headlight, signal and cab lights. Their incandescent headlight can be lighted every time the individual locomotive generator or the train lighting system as desired. A plate glass parabolic reflector is provided which is accurately ground to size and shape, and silvered to give a mirrored reflector. The manufacturer states that an incandescent lamp in this reflector seems to have a very high penetrating power. While being of a soft mellow color, does not have the blinding effect or an arc lamp on double track division.

VENTILATING EQUIPMENT.

B. W. Mudge & Co. report the development of a new combined blower ventilator, in which a modified Sturdevant blower of the multi wave type operates in conjunction with a Garland ventilator of special design. The motor of the blower is connected direct across the automatic switch and when the train is at rest the blower will maintain a reasonably good ventilation of the car. When the train gets up speed, however, and the generator becomes operative, closing the automatic switch, the blower motor is automatically cut out of service.

The *Horning Electric Mfg. Co.* of Cleveland, state that they have recently brought out an adjustable blower which is somewhat different in its design from other types, in that the velocity of exhaust is considerably

higher. The entire blower case can be revolved about the motor axis so as to make connections with the piping at any angle desired.

The *Railway Utility Co.* of Chicago, state that they have recently developed a new portable vacuum cleaner, the weight of which is but 10 pounds, yet cleans rugs and cushions with a powerful suction. When not in use this may be placed on the back of a locker door in the space ordinarily occupied by a broom.

The construction of the cleaner is simple and substantial. A small high-speed motor is direct connected to a fan, which creates the suction.

They also state that they have developed an electrical thermostat control for car heating systems, which will automatically control the temperature at any point desired from 60 to 74 degrees. Small platinum wires are sealed directly into a thermometer tube at certain points and a plug connection is provided so that an electrical contact may be made as the mercury rises to any certain point in the thermometer. Auxiliary apparatus is designed to control both steam heating and electric heating systems.

The *Vacuum Car Ventilating Co.* of Chicago, state that they have improved their device so that it now automatically cuts in additional electric heaters to take care of extremely cold weather.

They also state that they have re-designed their intake connection, which has resulted in reducing the weight.

WIRE AND WIRING DEVICES.

The *Belden Mfg. Co.* of Chicago, state that they have a newly equipped rubber wire plant and are now prepared to furnish all kinds of rubber covered, insulated wire. They also state that there has been a steady improvement in the uniformity, toughness and flexibility of the insulation on their enameled wire.

Mathias Klein & Sons of Chicago, advise that they have just developed a new insulation cutter. The purpose of this tool is to remove sections of insulation or wire so as to take out a connection and do it with a single operation instead of paring off with a Jack knife.

They also state that their new "Chicago Grip" has been designed for use on both plain and insulated wire.

Switches.

The *Hart & Hegeman Mfg. Co.* of Hartford, Conn., have developed a new miniature push button switch for car lighting circuits, particularly berth lights. The mechanism of this switch is similar to the standard house wiring switches and it can be furnished in both single pole and three-way types.

They have also brought out a fusable porcelain covered, 600-volt, barrier switch, in single pole, two-circuit and three-way types.

The *Bryant Electric Co.* of Bridgeport Conn., have brought out a new line of "Wrinklet" fixture sockets. These are of small size, especially designed for car fixture work.

They have also developed a complete line of small push button switches suitable for individual car circuits. This is made up with lock type and keys if desired.

MISCELLANEOUS.

The *Western Electric Co.* report a new semaphore signaling system. The semaphores, located at various siding where there are no operators, may be operated selectively by the dispatcher himself, and an answer back signal is also provided so as to indicate to the dispatcher that the semaphore has been properly set

Electric Welding.

The past year has witnessed a very active development in electric welding apparatus. This has been successfully applied to all work in the railroad field, such as repairing broken frames, broken spokes, broken axles and shafts, welding tubes in flue sheet, repairing cracked seams leaking portions of boilers, etc.

These welding outfits usually employ either graphite or Swedish iron electrodes, according to the class of work in hand. For railroad shops a malleable unit equipment is supplied, which permits of any number of operators working at any point in the shop at the same time from one single unit.

These welding outfits are now furnished by the Garwood Electric Co. of Garwood, N. J., the Lincoln Electric Co. of Cleveland, O., and the Simond Winzell Electric Welding Co. of New York.

Electric Tools.

The *Electro-Magnetic Tool Co.* of Chicago, has added a new and larger size to their line of electric hammers, particularly recommended for drilling holes up to 1½" in diameter in concrete and stone.

This tool, while operating in the same manner as do pneumatic tools, eliminates the necessity of air compressors and piping and has the advantage of being operated directly from lighting circuits.

The *Pyrene Fire Extinguisher* in its improved form is especially adaptable to electric railway service; not only in the power house but also in their cars. Pyrene is a non-conductor of electricity and therefore can be used on high voltages without damage.

Report of the Committee on Installation of Wiring for Electric Light and Power in Railway Buildings

Your Committee on Installation of Wiring for Electric Light and Power in Railway Buildings has held a number of meetings and is pleased to submit a report as follows

We have not considered it advisable to prepare any rigid or elaborate specifications; but rather offer some general recommendations and suggestions which, if followed in a general way, will result in giving a first class and thoroughly satisfactory installation.

We fully realize that local conditions will have considerable weight in determining the numerous details in any installation, as will also the personal experiences and views of the various engineers planning and installing the work.

In view of all these facts we have endeavored to present specifications and recommendations that will enable an engineer to make a perfectly safe and thoroughly up-to-date installation, and yet incorporate his individual ideas.

For convenience in considering this subject we have sub-divided it under eight heads as follows:

First: Round Houses.

Second: Machine Shops, Boiler Rooms and Engine Rooms.

Third: Store Rooms, Oil Rooms and Oil Storage Rooms.
Fourth: Coal Sheds and Coal Chutes.
Fifth: Cinder and Ash Pits.
Sixth: Passenger Stations.
Seventh Passenger Station Platforms.
Eighth: Freight Stations.

Taking these sub-divisions up in order we have:

First:—Round Houses. There are a number of methods in use for installing wiring in Round Houses. 1st. There is the outside wiring on the roof, where all service and circuit wires are carried either open on horses or other supports, or in conduit laid on the roof. The wires for the drops are run through the roof. This method is not to be recommended, as any cutting or boring of holes through the roof is objectionable. 2nd. The installation of open work wiring upon the ceiling of Round House, using the roof beams and boards as supports. While this method has given fairly satisfactory results in a number of instances, we would not recommend it. 3. The installation of the wiring in conduit carried under the floor. We believe that this method has not been adopted to any great extent and we would not recommend it. 4. The installing of all wiring in conduit, the latter carried either upon the outside of the outer wall, or upon the inside of same. This is the method we would recommend and submit the following specifications and recommendations.

All wires for this class of building should be placed in conduits. Conduits to be carried on either the outside of the outer wall or on the inside of the building. Where conduit is carried on the inside of the building it should be placed upon the outer wall over the windows and at as low a point as the windows will permit. For general illumination around a Round House we recommend the use of some type of headlight reflectors placed upon the outer wall in the stalls and approximately 8 to 12 feet above the floor. A very satisfactory arrangement is to place two such reflectors at the head of the stall and one at the foot.

For portable lamps it is advisable to run conduit down at least one post in each stall to a point about 6 to 6½ feet from the floor where a receptacle should be installed. For the extension use packing house cord fitted with a plug at one end and a weatherproof socket with handle and wire guard at the other end.

Conduits placed over 16 to 20 feet above the floor are subject to corrosion and should be avoided in all cases.

The permanent lights in each stall should be controlled by a switch located at some convenient point on the outer wall. The portable lighting circuit should be independent of other circuits and so connected as to be alive at all times except when main switch is open.

Second:—Machine Shops, Engine Room. and Boiler Rooms. There are practically only two methods of wiring for such buildings. 1st. The open or mill construction for lighting and conduit for power. 2nd. Complete conduit construction for both light and power. This is the method we would recommend and submit the following specifications and suggestions covering same.

Machine Shops. This wiring may be divided into two sections, for lighting and for power.

Lighting. For general lighting the wiring should be run in conduit overhead, provided with suitable outlet boxes at the desired locations. The lighting fixtures should be tungsten clusters or high wattage units. No drops should be used. Rigid fixtures are recommended. For the lighting of individual tools wires should be run in separate conduits under the floor to a receptacle located upon or near the tool. An extension should be provided, made up of a plug, a sufficient length of packing house cord and a weatherproof socket with handle and wire guard.

Power. The wiring for power should be run in conduit under the floor, and a separate circuit should be run direct from the panel box to each tool. All motors of over 5 horse power should be provided with starting apparatus having overload and no voltage attachments.

Each motor circuit should be controlled by fuses located in the panel box, and in no case should two or more motors be controlled by the same fuses.

Wiring for machine tool and other motors should be figured at the full capacity of the motor for each individual motor. The feeders supplying power circuits may be figured at 70 per cent of the total aggregate capacity of the motors it supplies.

All wires, supplying current to motors, where placed in conduit underground and subject to dampness, should be lead covered, with either rubber or paper insulation, or a high grade of rubber insulation with double braid.

It is recommended that the capacity of all fuses in panel boxes on motor circuits be 25 per cent more than that at which the overload switch at motor is normally set.

Engine Rooms. For general lighting the use of tungsten clusters or high wattage lamps is recommended, the cluster or single lamps to be located as requirements demand. The wiring should be run in conduit supported overhead from roof structure. where wiring is liable to be subjected to great heat, we would specify fireproof wire.

Each cluster or unit should be controlled by a switch located either in the panel box or at some other convenient point. Lamps suspended from ceilings on drop cords are not recommended.

In all cases where it is required to run conduits and wires on stationary engines for the purpose of illuminating the various parts of same, it is recommended that all such conduits start from the top of the engine and each branch be run down to either a light outlet or receptacle so that no oil can accumulate in either the vertical or horizontal runs of the conduit. It is further recommended that all conduit work around an engine be made water tight so as to avoid oil coming through the different fittings to the inside of same.

Boiler Rooms. For the illumination of steam and water gauges around boilers it is recommended that the conduits be run on top of boiler front and that fireproof wire be used. Where branches are to be taken off for the purpose of illuminating steam gauges and water glasses an extension tube or piece of conduit should be used in place of a drop cord.

For general illumination tungsten clusters or single high wattage lamps located over the firing space may be used. For illuminating the space back of the boilers, an entirely independent circuit should be run in conduit, with an outlet back of each battery of boilers. Each outlet to be provided with a weatherproof socket and wire guard. At this point provide a plug receptacle for each battery of boilers, for a suitable light to be used under and around boilers for cleaning purposes. For these portable lights we would recommend the use of "BX" flexible wire or some other wire having a non-combustable insulation.

Third: Store Houses and Oil Houses. All such buildings should be wired in conduit throughout. For Store Houses. We would recommend the use of single drop lights placed in the most desirable locations. Packing house cord should be used instead of the ordinary drop cord and all lamps should be provided with lamp guards. Switches for the control of lights may be placed in the most convenient locations; but the fuses protecting all circuits should be placed in metal panel boxes outside of the store room proper, preferably in the office.

Oil Houses. All conduit and fittings should be both water tight and vapor proof. All switches should be placed in a weatherproof box on the outside of the building. No switches nor key sockets should be allowed inside the building. All lights should be on rigid pendants provided with vapor proof sockets, vapor proof globes and wire guards. No drop cord of any kind should be used. Extreme care should be used in the wiring of Oil Houses so as to afford every possible protection from vapors.

Fourth. Coal Sheds and Chutes. The wiring for this class of structures should be in conduit throughout with the best grade of re-inforced cord where ever drop lights are needed. All lamps should be protected by wire guards. No fuses, switches, nor key sockets should be placed in rooms where coal dust is liable to accumulate in any great quantity, and all fuses should be enclosed in metal boxes.

Fifth.—Cinder and Ash Pits. Wiring for the lighting of such locations may be run in conduit underground or overhead on poles as conditions may indicate to be most desirable. Arc lamps, tungsten clusters or high wattage single lamps may be used; but we would recommend the use of clusters. The lamps should be placed at an angle of about 45 degrees on pipe brackets or goosenecks on poles at a height of about 18 to 20 feet.

Sixth.—Passenger Stations. It is recommended that all wiring be run in conduit. Where offices of any nature are to be located in the Passenger Station, we recommend that provision for extra circuits be arranged for by either of the following methods or a combination of same. First—Extra conduits should be run for additional circuits. Second—¾-inch conduit should be run to all such offices to provide for extra circuits. Third—In all cases provision should be made for extra circuits in the panel box.

As the lighting of Passenger Stations is very largely dependent upon the architectural features and the opinions of different persons, we have made no recommendations on this feature, leaving the matter wholly to the Engineer in charge of the work. The arrangement of circuits and location of switches should be such as would give the best control for economy.

Seventh.—Passenger. Station Platform Lighting. Should be run in conduit from the building underground to metal posts. These posts should be provided with a wiring space in the base covered by a weatherproof cover. All fuses for open platform lighting should be placed in the panel box in the building. This will probably frequently necessitate carrying more than 600 watts on an outside lighting circuit, which, in our opinion, is not objectionable for this class of service. We would further recommend the use of lead covered wire with rubber or paper insulation, or a high grade of rubber insulation with double braid.

Eighth.—Freight Stations. The wiring for all Freight Stations should be run in conduit. The office portion should be wired in the customary manner used in office buildings. In the ware room we would recommend the use of tungsten clusters or high wattage lamps at a proper height to properly illuminate the room. Drop lights are to be avoided where ever possible. Where drop lights are necessary, the best grade of drop cord should be used.

ESTIMATE.

Electric Wiring at..... For..... 19...

Amount.	Items.	Cost
	No. 14 B. & S. Insulated Copper Wire.....	
	No. 12 B. & S. Insulated Copper Wire.....	
	No. 10 B. & S. Insulated Copper Wire.....	
	No. .. B. & S. Insulated Copper Wire.....	
	No. .. B. & S. Insulated Copper Wire.....	
	No. .. B. & S. Insulated Copper Wire.....	
	No. 14. White Fire & Weatherproof Insulated Wire.....	
	No. 12. White Fire & Weatherproof Insulated Wire	
	No. 10. White Fire & Weatherproof Insulated Wire.....	
	No. .. White Fire & Weatherproof Insulated Wire.....	
	No. 10 H. D., T. B. Weatherproof Insulated Wire.....	
	No. .. H. D., T. B. Weatherproof Insulated Wire.....	
	No. .. H. D., T. B. Weatherproof Insulated Wire	
	No. .. H. D., T. B. Weatherproof Insulated Wire.....	
	Complete Two-Three Wire Cleats, No.....	
	Complete Split Knobs, No.....	
	Complete Split Knobs, No.....	
	Gross 2¼ in. No. 10 Wood Screws, (for knobs)	
	Gross 2 in. No. 10 Wood Screws, (for pipe straps)	
	Gross 1½ in. No. 8 Wood Screws, ¼ (for switches)	
	Gross 1½ in. No. 6 Wood Screws, (for cleats)	
	Gross 1¼ in. No. 10 Wood Screws, (for ceiling buttons)	
	¼-in. Circular Loom	
	½-in. Circular Loom	
	Knock-Down Cabinets, No..... Circuits.....	
	D. B. Combined Switch & Plub Fuse Cut-outs No. ..... (2 to 2 wire)	
	D. B. Combned Switch & Plub Fuse Cut-outs No. ..... (2 to 2 wire)	
	D. B. Combined Switch & Plub Fuse Cut-outs No. ..... (2 to 2 wire)	
	Pole Top-Buttom Service Switch & Plub Cutout No.	
	5 Ampere Snap Switches, No.	
	10 Ampere Snap Switches, No.	
	P. & S. Porcelain Snap Switch Bases No. 17	
	10 Ampere Enclosed Fuse Plub No.	
	30 Ampere Enclosed Fuse Plugs No.	
	Keyless Ceiling Receptacles, No. (Concealed Work.)	
	Keyless Ceiling Receptacles, No. (Cleat work.)	
	P. & S. Ceiling Buttons, No. 170	
	Fuseless Rosettes, No. .... (concealed work)	
	Key Sockets, No.	
	Keyless Sockets, No.	
	Weatherproof Sockets, No. ..... (6 wires)	
	No. 16 N. C. Standard Re-inforced Cord	
	Reflectors, Type .....No.	
	Reflectors, Holders Form	
	Deep Cone Shades, 10 in., No.	
	Shallow Cone Shades No.	
	Holdfast Wire Lamp Guards for 16 c. p. lamps.....	
	Portable Lamp Guards, No.	
	Hubble Side Wall Attachment Plug No. 5513	
	.....Watts Lamps ..... Volts	
	.....Watts Lamps ..... Volts	
	Cord Adjusters for Re-inforced Cord	

Amount.		Cost.
	3"5/16" Poreclain Tubes	
	1½"x5/16" Porcelain Tubes	
	Wire Painted Moulding for No. 14 Wire with cap	
	White Friction Tape	
	Black Friction Tape	
	Rubber Tape	
	Wire Solder	
	Soldering Paste	
	Soldering Compound	
	Gasoline	
	Alcohol	
	½-in. Conduit	
	¾-in. Conduit	
	in. Conduit	
	in. Conduit	
	Pipe Straps for.....in. Conduit	
	Pipe Straps for.....in. Conduit	
	Lock Nuts for.....in. Conduit.....	
	Lock Nuts for.....in. Conduit.....	
	Type..... Condulets No. ..... for.....in. Conduit	
	Type..... Condulets No. ..... for.....in. Conduit	
	Type..... Condulets No. ..... for.....in. Conduit	
	Type..... Condulets No. ..... for.....in. Conduit	
	Monitor Star Bushings for.....in. Conduit	
	Monitor Star Bushings for.....in. Conduit	
	½-in. Sheet Asbestos	

In General: We have purposely avoided recommending any particular make or brand of materials, but wish to state most emphatically that none but the very best materials on the market should be used. For conduit and fittings we recommend any of the standard grades of sherardized or galvanized. For wire we recommend only a high quality of rubber, paper, varnished cambric or other insulation.

As there are a number of good standard sockets, fuses, panel boxes conduit fittings etc. on the market,

we have left the specifying of such materials to the judgment of the Engineer.

We wish to call especial attention to the fact that the permanent value of an installation more often depends much more upon the quality of the workmanship than upon the quality of the materials used. Too great care in installing wiring cannot be exercised.

The National Board of Underwriters Code should be followed as closely as possible in all cases.

In order to assist the younger engineers in making up an estimate and a set of specifications, we give a typical list of materials to be used in installing the wiring in any ordinary class of railway building, such as a Passenger or Freight station. Catalog numbers and references have been omitted from this list. We advise the use of the catalog of any reputable concern as a standard reference in making up a list, knowing that, if the material is equal to that specified, it will be entirely satisfactory.

Respectfully submitted,

A. J. Farrelly, Chairman.
H. A. Gardner,
L. M. Gazin,
C. R. Gilman,
Frank Roblin,
A. S. Schulman.

Report of the Committee on Standards

Altoona, Pa., May 28, 1912.

Mr. D. J. Cartwright,
Chairman, Committee on Standards,
Association of Electrical Railway Engineers.

Dear Sir:

Your Sub-Committee on the question of standardizing ball bearings for axle generators submits the following as their recommendations.

First: Pulley and commutator end bearings should be the same size.

Second: The pulley end bearing should be a press fit within the limits given by the manufacturers of ball bearings. The bearing should be mounted directly on the axle. That is, construction requiring a sleeve for this bearing is not approved. The bearing should "Float," or in other words, should only be required to take radial load.

Third: The commutator end bearing should be mounted on a sleeve, and the bearing secured so that it will have no play longitudinally to the shaft. In other words, this bearing must be mounted so it will take the end thrust.

Fourth: Open ends of housing around each bearing should be provided with grooves, and the outer end of the housing for the pulley bearing should have two grooves and one felt washer.

Fifth: Each bearing must be mounted on the shaft between a shoulder and nut, and locked securely in place.

Sixth: The size bearing should be that known as the 412.

Seventh: The nipple for the grease gun shall be of 3/8" pipe, with standard pipe thread, properly capped.

Eighth: The question of standardizing the pulleys was discussed at length but as standardizing the pulleys affected all generators now in service, and as each make of generator uses a pulley that differs in some essential dimension from pulleys of all other makes it was thought best that this question be referred back to the Committee on Standards. It was admitted by all that from the engineering side there was no reason why the pulleys could not be made standard, and further that from the operating side it would be advantageous to do so. From the commercial side, however, the fact that of the pulleys that have been supplied by the manufacturers no two makes are interchangeable and that there are thousands of these pulleys and shafts in existence, was considered of such importance that your Committee, as a whole, did not feel that they could make any recommendations.

Some of the members of the Committee, while appreciating the point of view taken by the others, namely, the objections from the commercial side, felt that undue weight was given those objections. The other members did not understand the position taken by those favoring the adoption of a standard pulley. The view these members took of the matter was that the railroads now have to carry in stock various shafts and pulleys—that these shafts and pulleys wear out or are broken, and that when remodeling generators to the ball bearing type new shafts and pulleys could be ordered in accordance with the standard recommended. This procedure would entail carrying extra shafts and pulleys, but eventually would result in all pulleys being interchangeable on all ball bearing generators, and this condition would be a decided advantage to the railroads and would not be a hardship on the manufacturers, provided the Railroad Companies in ordering shafts and pulleys would clearly specify what they wanted.

The Committee does, however, recommend that the armature shaft pulley keys shall be of 3/8" square stock and the key-way in the shaft and pulley bore shall be cut parallel to the axis of the shaft.

The Committee also discussed the question of lubricant to be used with the ball bearings and recommends that this lubricant shall conform to the following:

First:—Shall not, when new, contain either free acid or alkali.

Second:—Shall not, when old, contain free acid.

Third:—Shall not oxidize or materially evaporate.

Fourth:—Shall not pound thin in service.

Also that the lubricant shall be applied as follows:

Before placing generator in service for the first time the bearings shall be filled with lubricant. When the generator is in service the lubricant is to be injected with a "Gun" at such intervals as the Railroad Company may determine is necessary.

Respectfully submitted,

J. R. Sloan, Chairman.
W. L. Batt,
W. L. Bliss,
W. F. Buoche,
T. V. Buckwalter,
H. E. Hulse,
N. E. Lemmon,
T. L. Mount,
R. M. Newbold,
F. H. Poor,

Report of the Committe on Specifications

The Chairman of the Committee on Specifications was authorized by your President to extend to such persons as he might desire, an invitation to become members of the said Committee. This privilege was exercised and in extending these invitations the Chairman did not limit himself to the membership of the Association but included such gentlemen of his acquaintance as were most familiar with the various subjects under consideration, and who, by their knowledge, could contribute to the writing of the specifications.

The work of preparing these specifications was divided among Sub-Committees, each Sub-Committee in charge of a Chairman who was a member of the Association.

Your Committee herewith submits, as their report, specifications for the following:

Canvass Belting for driving axle generators.

Wire, 0-750 volt service.

Incandescent Lamps.

It is the hope of the Committee, that if their specifications are drawn in such a manner that they are acceptable to the membership, that each member will exert himself to secure their official adoption by the Road that he represents.

J. R. SLOAN, Chairman.

SPECIFICATIONS FOR BELTING FOR AXLE GENERATORS.

Ordering.

1. These specifications cover all belting for axle generators for use on the A. B. & C. Railroad. Belting in accordance with these specifications will be ordered in rolls of approximately 500 feet as the needs of the service demand. The width of the belting should be specified in the order. Stitched belting properly coated with a water proof composition may be ordered, but it must be so specified in the order.

Material Desired.

2. All rubber belting shall have five plys of friction duck with a 1/32 inch rubber cover. The friction shall require a pull of 20 pounds to separate the plys of duck on a sample one inch in width. The duck shall have a tensile strength, of 350 pounds per inch of width. It is also desired that the stretch shall be taken out of the belt, in order that when the full width is tested, as hereinafter mentioned, the stretch in 18 inches shall not be more than one inch. The duck in stitched belting shall have a tensile strength of 300 pounds per inch of width and a stretch in 18 inches of not more than 1½ inch.

Badge Plate.

3. The badge plate shall be placed on the belt at distances of 9 feet apart and be of the same color of rubber as the cover. It shall conform to size and dimensions of cut below and figures of the serial number shall not be less than 3/8 of an inch in height and 1/32 of an inch in relief. This serial number shall commence with one at the beginning of the year and continue consecutively throughout the year. No badge place will be required on stitched belting.

Method of Sampling.

4. When the belting is received at Store House a sample three feet long shall be cut from any part of a whole or fractional roll and forwarded to the..... ..... accompanied by a sample for test tag, giving the following information:

a—Number of feet represented by the sample.
b—Serial number.
c—Name of manufacturer.
d—Name of shop.
e—Requisition number.

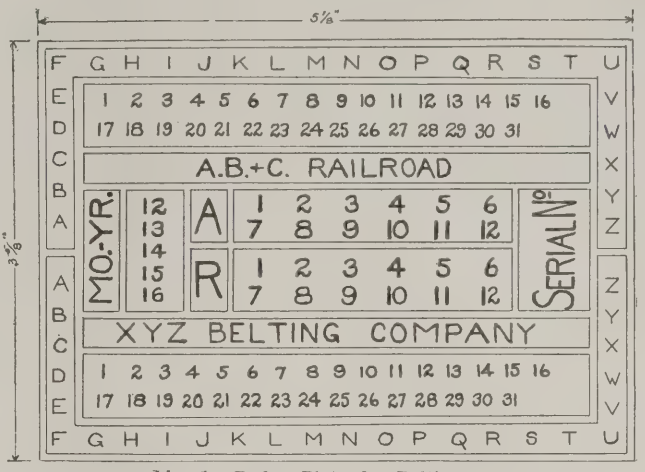


Fig. 1. Badge Plate for Belting.

Method of Testing.

5. When the sample is received by the————it will be subjected to the following tests, except in case of stitched belting, no friction test will be made.

5a. A section of 6 inches in length shall be cut from the sample and from this a strip one inch in width, shall be cut on the longitudinal axis of the belt. The friction shall be determined from this sample, by weighing the pull necessary to start the separation of the plys of duck. The test shall be made in a tensile test machine at a speed of 6 inches per minute. The pull necessary to start the separation of the duck shall be taken at three diffierent points and the average of these three readings, shall be used in accepting or rejecting the material.

5b. Another section 1½ inch in width shall be cut from the 6 inch length and used to determine the tensile strength of the duck. One ply of duck shall be removed from this section, placed in the tensile test machine and the strands in the warp shall be removed from each side until the section is exactly one inch in width. Load will be applied by machine running at a rate of 6 inches per minute and the pull necessary to break the duck will be observed.

5c. Marks 18 inches apart shall be placed on the remaining 30 inch length of sample using the full width of the belt, and it shall be placed in tensile test machine for the purpose of making stretching tests. A load shall be applied equivalent to the product of the number of plys of duck times the width in inches times 200. Under this load the elongation shall be measured and the belt must not break or the elongation be more than that required under rejection limits.

Rejection Limits.

6. A roll of rubber belting shall be rejected if:

a—The thickness exceeds 0.30" or is less than 0.20".

b—Average results obtained on friction tests are below 18 pounds.

c—Tensile strength of one ply of duck 1" in width is less than 300 pounds.

d—Stretch in 18" exceeds 2".

6a. A roll of stitched belting shall be rejected if:

a—Thickness exceeds 0.30" or less than 0.20".

b—Tensile strength of one ply of duck 1" in width is less than 250 pounds.

c—Stretch in 18" exceeds 2½".

6b. Individual rolls may be repected at the shops if they vary more than 3/16 of an inch either way from the specified width or if the edges are not straight.

Claim for Rehearing.

7. The test samples representing the rejected belting shall be preserved at the Test Department for one month from date of test report. Accordingly, in case of dissatisfaction with the result, manufacturers must make claim for a rehearing, should they desire to do so, within that time. Failure to raise a question for one month shall be construed as evidence of satisfaction with the tests, the samples shall be scrapped and no claim for rehearing will be considered.

Freight Charges.

8. Manufacturers and shippers must pay freight charges both ways on all rejected material.

J. R. Sloan, Chairman.
J. M. Craig.
J. P. Puette.

SPECIFICATIONS FOR THE PURCHASE OF INCANDESCENT LAMPS.

Your Committee appointed to look into the subject of Standard Specifications for the Purchase of Incandescent Lamps have performed the duties assigned them and present herewith report of their labors.

Necessity for Standard Specifications.

The manufacturers of incandescent lamps have a standard form of specifications which they recommend to their customers. The large majority of their customers are, however, local lighting and power companies and isolated plants in office buildings. Such customers do not have to meet the conditions of operation that railroads encounter. The public at large generally demands from a railroad much more in the line of comfort, convenience, and safety than it will provide for itself.

Furthermore, the manufacturers' specifications are drawn to cover all sizes, types, and kinds of lamps. Your Committee can see no necessity for any railroad covering the entire variety of lamps manufactured and the demands of the public are so severe that we feel the Association is warranted in adopting a set of specifications standard only for railroad work. Copy of the specifications recommended by the Committee is attached hereto.

General Form of Specifications.

The specifications should be divided into two parts. Part One, covering the requirements to be met by the manufacturers and reciting in detail the methods of inspection and test by the purchaser; and Part Two, covering instructions relative to the purchase and use of lamps. Part Two is made necessary to a large extent, by reason of the extremely large number of orders that reach the manufacturer giving him very little, if any, information concerning the particular lamp it is desired to purchase.

PART ONE.

Part One is subdivided into six parts as follows:

General Requirements.
Definitions and Standards.
Method of Inspection and Test.
Physical Characteristics.
Electrical Characteristics.
Schedules.

In the specifications the subdivisions are arranged in order above mentioned, it being out thought that this is the most logical arrangement.

General Requirements.

Under General Requirements we have a statement of those things that apply in a general way, such as a description of the facilities for test and inspection that will be required, some statement as to what lamps will be inspected or tested, the rating to be used, etc.

Definitions and Standards.

Under this subdivision we have the definitions of the terms used and descriptions of the standards adopted such as: the unit of candle power, photometric measure, reduction factor, lot, etc.

Method of Inspection and Test.

This subdivision describes the method of inspection and test in detail, giving the number of sample lamps required for each individual inspection or test as well as quantities of defective lamps necessary for rejections.

Physical Characteristics.

In this subdivision is given the various physical defects that will be looked for by the inspector, such as defects in the glass, the base, the filament, the leading in wires, etc.

Electrical Characteristics.

Here we have recited the electrical characteristics to which the lamps must conform, specifying clearly and in detail the method of conducting life performance and other electrical tests.

Schedules.

The schedules specify the initial rating, inspection limits, life performance, etc., of all the lamps recommended by your Committee for railroad use. It is thought that the railroad demand can be confined to the following schedules:

Schedule	Class	Filament
G	100 to 130	Metallized
T	100 to 130 z	Tungsten
T	200 to 260	Tungsten
T. Tr. Ltg.	Train Lighting	Tungsten
G Ry	Series Burning	Metallized
T Ry	Series Burning	Tungsten
T. S. S.	Street Series	Tungsten

Schedule for 200 volt tungsten, series burning metallized, and series burning tungsten lamps will not be ready for incorporation in the Specifications until the date of the Convention.

Carbon filament lamps cannot be included in yearly contracts and as the railroad company's specifications are generally made a part of the contract, they should not appear in these specifications. If specifications for carbon filament lamps are desired, they should be worked up separately, conforming, so far as possible, to our standard specifications.

PART TWO.

Part Two is intended to specify what lamps can be ordered and to state clearly the information it is necessary to give on requisitions in order that they may be filled promptly by the manufacturers. Some of the railroads may find it necessary or desirable to issue more or less special instructions to their employees concerning the ordering or use of incandescent lamps. Such instructions should be included in Part Two.

Excess Voltage Test.

In the inspection and test of all classes of materials by railroads, the endeavor is made to arrange for all tests to be completed within the period of a ten hour working day. Some years ago, before the introduc-

tion of metallized filament, tantalum, and tungsten filament lamps, a quick test, that could be completed within a nine or ten hour working day, was worked out and used by several of the Eastern railroads. This test is known as the "excess voltage" test on account of the application, during the test, of a voltage somewhat higher than that for which the lamp is rated. To conduct such a test successfully, in a manner fair to both purchaser and manufacturer, requires a thorough knowledge of lamps, their characteristics, methods of manufacture, etc., on the part of the test officer, and test must be conducted with extreme care and accuracy. It is not advisable for anyone to undertake this test until after they have had several years experience in the inspection and test of incandescent lamps.

With carbon filament lamps, excess voltage test results checked fairly well with those secured on normal voltage test, so that the test was deemed reliable enough to determine whether the lamps should be accepted or rejected. With the introduction of metallized filament, tantalum and tungsten lamps, conditions were changed and the results obtained upon excess voltage test do not check consistently with the results obtained on normal voltage life test. Then again the improvements made in the several modern types of lamps have been so rapid that today we have no reliable data on which to base an accurate excess voltage test. It is possible that, at some future date, a reliable excess voltage test may be worked out. For the present, however, excess voltage test results may be taken only as an indication of quality and must not be taken as a measure of what the lamps will do under normal conditions of operation. For these reasons your Committee does not think it wise to recommend at this time, the use of the excess voltage test.

Recommendations.

Your Committee believes that great good will result if the railroads can be united on one common set of specifications for the purchase of incandescent lamps. The accompanying specifications are thought to be drawn sufficiently close to meet all the requirements of railroad work and are in accord with railroad practice. We not only recommend the adoption of these specifications by the Association, but also that the several members of the Association recommend their adoption by the railroads they represent.

A B & C RAILROAD.

No. 000.

Specifications for the Purchase of Incandescent Lamps.

These specifications consist of two parts. Part One covering the requirements to be met by the manufacturers, and the inspection of lamps by the Purchaser, and Part Two, covering instructions relative to the purchase and use of lamps.

Part One.

GENERAL REQUIREMENTS.

Facilities for Inspection at Factory.

1. Manufacturers shall furnish satisfactory and suitable facilities for inspection, initial testing, shipment, and such other assistance as will enable the Inspector to inspect and test lamps in accordance with these specifications.

Physical and Electrical Test and Inspection.

2. These specifications shall not apply to any frosted or colored lamps, or to lamps other than those with the usual clear glass bulbs, unless otherwise specifically included. Frosted lamps shall be represented in initial tests, inspection and life tests by clear lamps. All lamps purchased shall be subject to inspection and test for physical defects and initial rating. Only such lamps as are specifically mentioned in the several schedules for different classes of lamps will be subject to life test. Should it become desirable to correct the several schedules on account of changes in the art, or to make additions on account of the purchase in quantity of lamps not specifically mentioned, new limits which have been agreed to in writing by the Purchaser and the Manufacturer may be substituted or added hereto.

Voltage Rating.

3. All lamps furnished in accordance with these specifications shall be rated at highly operating efficiency voltage and will be inspected and tested for candle powers, amperes, or efficiencies corresponding to high operating efficiency voltage.

DEFINITIONS AND STANDARDS.

Unit of Candle Power.

1. The unit of candle power shall be the International Unit as maintained by the Bureau of Standards, Washington, D. C.

Photometric Measure.

5. The basis of comparison of all lamps shall be the mean spherical candle power. The nominal or rated candle power to which reference is made in these specifications shall be the mean horizontal candle power based on reduction factors given in the several schedules for different classes of lamps. All readings for mean horizontal candle power shall be made with lamps rotating at a speed sufficient to overcome flickering.

Determination of Reduction Factors.

6. For all lamps having filaments giving a different initial ratio of mean spherical to mean horizontal candle power, the mean horizontal candle power measurements shall be corrected by reduction factors determined by the Bureau of Standards, Washington, D. C.

"Lot" of Lamps.

7. The word "lot" when used in these specifications shall mean

A group of packages of the same kind, size, and type and voltage, groups of lamps not to exceed a total of six hundred (600) lamps.

METHOD OF INSPECTION AND TEST.

Place of Inspection.

8. Inspection for physical defects and tests for initial values of candle power and watts, will be made at the place of manufacture. Tests for life performance will be made at some point designated by the Purchaser other than the place of manufacture.

Notification of Purchaser.

9. Manufacturers shall notify the Purchaser when lamps are ready for inspection and shall await their acceptance by the Purchaser's Inspector before shipment of lamps.

Inspection and Rejection for Physical Defects.

10. The Inspector will examine for physical defects five (5) per cent. of each lot of lamps offered, the inspection covering not less than ten (10) lamps. Should more than twenty (20) per cent., of the lamps examined show any defects incompatible with good workmanship, good lighting service, or any clause of these specifications, the lot of lamps represented by this examination will be rejected.

Test and Rejection for Initial Rating.

11. The Inspector will examine for initial rating all of the lamps selected for inspection for physical

defects. They shall be tested at high operating efficiency voltage, amperes, or candle power, as shown in their respective schedules. The failure of more than twenty (20) per cent. of the lamps so tested to come within the limits prescribed in their respective schedules, will be sufficient cause for the rejection of the lot represented by this examination.

Samples for Life Candle Power Test.

12. From each lot of lamps which have passed the inspection for physical defects and tests for initial rating, two (2) per cent. or the nearest even number of whole lamps, which approximate most closely to the normal rating of the lamps as to total watts and candle power may be selected for use in the determination of the life and candle power performance, and shipped to the point designated by the Purchaser.

Sealing of Packages.

13. All packages of lamps which have passed the factory inspection shall be marked for indentification by the Inspector and packages must not be shipped until so marked and finally accepted.

PHYSICAL CHARACTERISTICS.

Physical Requirements.

14. The lamps shall be well made and free from all defects, as herein specified and such other defects as in the judgment of the Inspector will render the lamps unfit for service.

Bulbs.

15. Unless otherwise specified, clear lamps shall be furnished. All bulbs shall conform to the dimensions given in the Manufacturers' schedules and shall be uniform in shape, clear, clean and free from flaws or blemishes detrimental to the service, and in the case of tipped lamps, tips shall not be long or blackened.

Bases.

16. Unless otherwise specified, all lamps shall be furnished with Standard Screw Bases. The shells of the base shall be made of good quality brass, firmly and accurately fitted to the bulb, and all bases shall be impervious to moisture. When bases have extended skirts, same shall be insulated from the shell.

Filaments.

17. The filaments of all lamps shall be placed symmetrically in the bulb, and shall be uniform and free from imperfections, spots, and discolorations detrimental to the service.

Leading-In Wires.

18. Leading-in wires shall be fused in the glass with the joint between the copper and platinum wires bedded well within the glass, must be straight, well separated, and soldered to the base and cap without excess of solder. The threads of the base must be free from solder.

Vacuum.

19. The lamps must have suitable vacuum, showing the characteristic glow for each size when tested on an induction coil.

20. One or more printed labels, showing rating and manufacturers name or trade mark, shall be placed on the bulb near the base of the lamp. Trade names, trade marks, or other devices when etched, painted or marked on the glass shall be of small letters or figures as near the base as possible.

ELECTRICAL CHARACTERISTICS.

Check for Initial Rating.

21. On receipt at the point designated by the Purchaser, of the lamps selected for life candle power performance in accordance with paragraph No. 12 they will be checked for initial rating and subject to the test described in paragraphs Nos. 22 and 23.

Life and Candle Power Maintenance.

2. For the determination of the life and candle power maintenance of any lot of lamps, fifty (50) per cent. and in no case less than four (4) lamps, of the lamps selected as described in paragraph No. 12 shall be tested for candle power performance as follows:— The lamps will be photometered and the voltage determined which will give the watts per candle specified in the several schedules. The lamps will be burned at this voltage throughout the test. During the test, variations in voltage shall not exceed one-half (½) per cent. above and one-half (½) per cent. below the normal voltage.

Candle Power Readings at Test Voltage.

23. Candle power readings shall be taken when the lamps shall have burned approximately fifty (50) hours, and at least every one hundred (100) hours thereafter, until the candle power shall have decreased to less than eighty (80) per cent. of its initial value. The number of hours each lamp burns until the candle power has decreased to eighty (80) per cent of its initial value or until the lamp fails, if within that period, is known as the test life.

In computing the results of life test of any lot of lamps, the average hours life shall be the arithmetical mean of the values for the individual lamps.

Lamps which are broken, but not burned out during test, shall not be counted to diminish the average performance.

Rejection and Report.

24. If the average test life of any lot of lamps is less than ninety (90) per cent. of the test life values specified in the several schedules, the lot of lamps represented by the test samples will be rejected. Notification of the final acceptance or rejection of lamps as well as life diagrams of rejected lamps will be mailed promptly to the manufacturer upon completion of each test. Samples of rejected lamps will be preserved by the Purchaser at the Laboratory one month from date of test report. In case of dissatisfaction with the results of tests, the manufacturer shall make claim for a hearing within that time, and the failure to raise a question within one month from date of test will be construed as evidence of satisfaction with the tests, the samples will be disposed of, and no claim for a hearing will be considered.

SCHEDULE G

This schedule applies to large, clear, oval-anchored, metallized filament lamps of from 100 to 130 volts, for multiple burning.

The initial rating, limits and performances listed below apply only to lamps operated at righ operating efficiencies.

Initial Rating, Limits, and Performance

Reduction Factor 82.5 per cent.

Initial Rating			Initial Limits C. P. Limits Above and below		Initial Limits Tot. watt limits Above and below		Avg. Performance Test life hrs. to 20% drop in C. P. at W.P.M.S.C.P.		
Watts	Candle Power	W. P. C.	Individual	Average	Individual	Average	W. P. M. S. C. P.	Test Life	Bulb
30	10.0	3.00	10.0%	6.0%	10.0%	7.0%	3.64	700	S-17-A
40	15.6	2.56	7.5%	5.0%	7.0%	5.0%	3.11	400	S-19-A
50	20.0	2.50	7.5%	5.0%	7.0%	5.0%	3.03	500	S-19-A
60	24.0	2.50	7.5%	5.0%	7.0%	5.0%	3.03	500	S-19-A
80	32.5	2.46	7.5%	5.0%	8.0%	5.0%	2.98	500	S-24-A

For lamps from 126 to 130 volts, inclusive, the best life value shall be 90 per cent. of those given in the table.

Lamps having double the limits of variation in initial limits specified above, may be supplied on all orders calling for lamps of 105 volts and below, 110 and 121 volts and above.

SCHEDULE T.
100 Volt Class

This schedule applies to large, clear, tungsten filament lamps of from 100 to 130 volts, for multiple burning.

The initial ratings, limits, and performances listed below apply only to lamps operated at high operating efficiencies.

Initial Rating, Limits, and Performance

Reduction factor 15 to 250 watt lamps inclusive, 78 per cent.

Reduction factor 400 and 500 watt lamps, 81 per cent.

Initial Rating.			Initial Limits.		Average Performance.	Bulb.	
	*Watts per Candle		Individual W. P. C. Max. & Min.	Individual Tot. Watts Max. & Min.	Test life in hours to 20% drop in C. P. when tested at initial rated efficiency.		
Watts	Col.A	Col.B				St. Side	Spherical
15	1.31	1.30	8%	20%	1000	S-17-B	G-18-½-B
20	1.28	1.25	8%	20%	1000	S-17-B	G-18-½-B
25	1.23	1.17	8%	15%	1000	S-19-C	G-25-A
40	1.18	1.12	8%	15%	1000	S-21-E	G-30-C
60	1.16	1.10	8%	15%	1000	S-24-½-A	G-40-A
100	1.13	1.07	8%	15%	1000	S-30-A	
150	1.12	1.05	8%	15%	1000	S-35-A	
250	1.10	1.00	8%	15%	1000	S-40-B	
400	1.10	1.00	8%	15%	1000		G-56-A
500	1.10	1.00	8%	15%	1000		G-64-A

*Column A to apply until changed by notice from manufacturer. Column B to apply upon notice from manufacturer. When change is made, in whole or in part, new schedule will be furnished by manufacturer.

For lamps from 126 to 130 volts, inclusive, the best life value shall be 90 per cent of those given in the table.

Lamps having double the limits of variation in initial limits specified above, may be supplied on all orders calling for lamps of 105 volts and below, 110, and 121 volts and above.

SCHEDULE T. TR. LTG.

This schedule applies to large, clear, tungsten lamps of from 25 to 34 and 50 to 65 volts, for multiple burning in train lighting service.

Initial Rating, Limits, and Performance

Reduction factor 79 per cent.

Initial Rating.					Initial Limits.		Average Performance.		Bulb.	
Watts			*Watts per Candle		Individual Volts Max. and Min.	Individual Watts. Max.	Test life in hours to 20% drop in C. P. at W.P.M.S. C.P.			
Rated	Actual	Candle Power	Col.A	Col.B			W.P.M.S. C.P.	Test Life	Spherical	St. Side
10	10.00	8	1.25	1.25	5%	8%	1.58	1000	G-18-½-B	S-17 or S-19
15	14.76	12	1.23	1.17	5%	8%	1.56	1000	G-18-½-B	S-17 or S-19
25	24.60	20	1.23	1.17	5%	8%	1.56	1000	G-18-½-B	S-17 or S-19
50	49.20	40	1.23	1.17	5%	8%	1.56	1000	G-30-C	S-21

*Column A to apply until changed by notice from manufacturer. Column B to apply upon notice from manufacturer. When change is made, in whole or in part, new schedule will be furnished by manufacturers.

SCHEDULE G. R'Y.

This schedule applies to large, regular clear metallized filament lamps for street railway, series burning. These lamps shall be rated in the following voltage groups

105 volts for use 5 in series on 525 volts.
110 volts for use 5 in series on 550 volts.
115 volts for use 5 in series on 575 volts
120 volts for use 5 in series on 600 volts.
125 volts for use 5 in series on 625 volts.
130 volts for use 5 in series on 650 volts.

Each voltage group shall embrace a range in amperes five (5) per cent. above and five (5) per cent below the nominal ampere value obtained by dividing the product of the initial candle power and actual initial watts per mean horizontal candle power, by the voltage of the group. The lamps will be marked and packed in .01 ampere steps throughout this range.

When the annual requirements of the purchaser for any voltage group and wattage is less than three hundred dollars ($300.00) the manufacturer shall supply lamps of one of the .01 ampere ranges. When the annual requirements exceed three hundrd dollars ($300.00) the manufacturer shall have the privilege of supplying lamps of at least two of the .01 ampere steps.

Initial Rating, Limits and Performance.

For lamps tested at initial candle power.

Reduction factor 82.5 per cent.

Each .01 ampere step shall be within the limits shown.

Initial Rating.		Initial Individual Limits Above & Below.			Initial Indivd. Limits Above & Below.			Average Performance. Test life in hrs to 20% drop in C. P. at W. P. M. S. C. P.	Bulb
Watts per Lamp	Candle Power	Amperes	Watts	Volts	Amperes	Watts	Volts	W.P.M. S.C.P.	Test Life.
35	11.0	3.0%	8.5%	5.5%	1.5%	6.0%	4.5%	3.11	400
54	18.0	2.0%	7.0%	5.0%	1.2%	5.0%	3.8%	3.03	500

Initial Rating, Limits and Performance.

For lamps tested at rated amperes.

Reduction factor 82.5 per cent.

If the purchaser so elects, this table may be substituted for the one above.

Initial Rating. Watts		Initial Individual Limits Above & Below.		Initial Average Limits Above & Below.		Average Performance. Test life in hrs to 20% drop in C. P. at W. P. M. S. C. P.		
per Lamp.	Candle Power.	Candle Power.	Watts.	Candle Power.	Watts.	W.P.M. S.C.P.	Test Life.	Bulb.
35	11.0	18.0%	8.5%	6.0%	6.0%	3.11	400	
54	18.0	15.0%	7.0%	5.0%	5.0%	3.03	500	

For lamps in the 105, 125, and 130 volt groups, the limits of variation in the initial limits shall be double those given in the tables.

For lamps in the 120, and 125 volt groups, the test life values shall be ninety-five (95) per cent. of the values given in the tables.

For lamps in the 130, volt group, the test life values shall be ninety (90) per cent. of the values given in the tables.

Requisitions.

26. Requisitions should cover the following data:
   (1) Quantity desired (Standard package quantities).
   (2) Rating of lamp in watts. (25 watt, 40 watt, etc.)
   (3) Voltage or amperes. (103 volt, 3.5 amp., etc.)
   (4) Bulb (S-17, C-40-A, etc.)
   (5) Kind of filament. (Metallized, tungsten, etc.)
   (6) Service for which lamp is intended. (Multiple burning, train lighting, etc.)

Examples of Requisitions.

27. Examples of how requisitions should read are as follows:

100, 25 watt, 113 volt, Tungsten filament, multiple burning lamps.

100, 15 watt, 60 volt, G-18-½-B, Tungsten train lighting lamps.

Clear and Frosted Lamps.

28. Clear lamps will be furnished on all requisitions unless otherwise specified. If bowl frosted, full frosted or colored lamps are desired, the order should clearly so specify.

Telegraphic Orders.

29. Owing to the excessive cost of inspecting rush orders, store keepers should carry a sufficient stock of each kind, size, and type of lamp so that telegraphic orders will be unnecessary

Three Voltage Label.

30. Manufacturers use a three-voltage method of rating lamps. Only one voltage should be specified on requisitions and the voltage so specified will be the "top" voltage marked on the label pasted on the lamp. This "top" voltage is known as "high operating efficiency voltage."

Part Two.

INSTRUCTIONS RELATIVE TO THE PURCHASE AND USE OF INCANDESCENT LAMPS.

List of Lamps.

25. Only the lamps listed below can be inspected and tested for life performance by the Test Department. Lamps not listed can be inspected only for physical defects and initial rating. Requisitions should therefore be confined as much as possible to the lamps given in the following list:

Package. Standard G. E. CO.	W. L. Co.	N.E.L.A.	Rating, Watts or Candle Power.	Voltage or Amperes.	Filament.	Bulb.	Service.
200	250	250	30 W.	100 to 130 Volts	Metallized	S-17-A	Mult. Burning
200	250	250	40 W.	100 to 130 Volts	Metallized	S-19-A	Mult. Burning
200	250	250	50 W.	100 to 130 Volts	Metallized	S-19-A	Mult. Burning
200	250	250	60 W.	100 to 130 Volts	Metallized	S-19-A	Mult. Burning
100	100	100	80 W.	100 to 130 Volts	Metallized	S-24-A	Mult. Burning
100	100	100	15 W.	100 to 130 Volts	Tungsten	S-17-B G-18-½-B	Mult. Burning
100	100	100	20 W.	100 to 130 Volts	Tungsten	S-17-B G-18-½-B	Mult. Burning
100	100	100	25 W.	100 to 130 Volts	Tungsten	S-19-C G-25-A	Mult. Burning
100	100	100	40 W.	100 to 130 Volts	Tungsten	S-21-E G-30-C	Mult. Burning
50	50	50	60 W.	100 to 130 Volts	Tungsten	S-24-½-A G-40-A	Mult. Burning
24	24	24	100 W.	100 to 130 Volts	Tungsten	S-30-A	Mult. Burning
24	24	24	150 W.	100 to 130 Volts	Tungsten	S-35-A	Mult. Burning
12	12	12	250 W.	100 to 130 Volts	Tungsten	S-40-B	Mult. Burning
8	8	8	400 W.	100 to 130 Volts	Tungsten	G-56-A	Mult. Burning
8	8	8	500 W.	100 to 130 Volts	Tungsten	G-64-A	Mult. Burning
Schedule for 200 to 260 Volt Tungsten lamps to be inserted here at later date.							
100	100	100	10 W.	25 to 34 Volts	Tungsten	S-17	Train Lighting
100	100	100	15 W.	25 to 34 Volts	Tungsten	S.-19	Train Lighting
100	100	100	25 W.	25 to 34 Volts	Tungsten	G-18-½-B	Train Light.
24	24	24	50 W.	25 to 34 Volts	Tungsten	S-21 G-30-C	Train Lighting
100	100	100	10 W.	50 to 65 Volts	Tungsten	S-17 S-19	Train Lighting
100	100	100	15 W.	50 to 65 Volts	Tungsten	G-18-½-B	Train Light.
100	100	100	25 W.	50 to 65 Volts	Tungsten		Train Lighting
24	24	24	50 W.	50 to 65 Volts	Tungsten	S-21 G-30-C	Train Lighting
Schedule for Series burning Metallized filament lamps to be inserted here at a later date.							
Shedule for Tungsten Series burning lamps to be inserted here at a later date.							
50	50	50	32 CP	3.5, 4.0, 5.5, 6.6, and 7.5 Amp.	Tungsten	S-27-½-A	St. Series B.
50	50	50	40 CP	3.5, 4.0, 5.5, 6.6, and 7.5 Amp.	Tungsten	S-27-½-A	St. Series B.
50	50	50	60 CP	3.5, 4.0, 5.5, 6.6, and 7.5 Amp.	Tungsten	S-27-½-A	St. Series B.
24	24	24	80 CP	3.5, 4.0, 5.5, 6.6, and 7.5 Amp.	Tungsten	S-35-C	St. Series B.
24	24	24	100 CP	4.0, 5.5, 6.6 Amp.	Tungsten	S-35-C	St. Series B.
12	12	12	200 CP	4.0, 5.5, 6.6, 7.5 Amp.	Tungsten	S-40-B	St. Series B.
8	8	8	350 CP	4.0, 5.5, 6.6 Amp.	Tungsten	G-64-A	St. Series B.

SCHEDULE T. S. S.

This schedule applies to large, clear, tungsten lamps of from 3.5 to 7.5 amperes, inclusive, for street series burning.

Initial Rating, Limits, and Performance

Reduction factor 77 per cent.

Initial Rating. Labeled C. P.			Initial Limits at Average Performance.		Test life hours to 20% drop in C. P. at W. P. M. S. C. P.		Bulb.	
Candle Power.	Ampere Ranges.	W. P. C.	Individual Amp. Limits Above and Below.	Individual Watt Limits Above and Below.	W.P.M. S.C.P.	Test Life.	St. Side	Spherical*
	3.5	1.22	3.0%	8%	1.58	1350	S-27-½-A	
	4.0	1.26	2.5%	8%	1.63	1350	S-27-½-A	
32	5.5	1.32	1.8%	8%	1.71	1350	S-27-½-A	
	6.6	1.41	1.5%	8%	1.83	1350	S-27-½-A	
	7.5	1.48	3.0%	8%	1.92	1350	S-27-½-A	
	3.5	1.20	3.0%	8%	1.56	1350	S-27-½-A	
	4.0	1.22	2.5%	8%	1.58	1350	S-27-½-A	
40	5.5	1.27	1.8%	8%	1.65	1350	S-27-½-A	
	6.6	1.32	1.5%	8%	1.71	1350	S-27-½-A	
	9.5	1.36	3.0%	8%	1.77	1350	S-27-½-A	
	3.5	1.18	3.0%	8%	1.53	1350	S-27-½-A	
	4.0	1.18	2.5%	8%	1.53	1350	S-27-½-A	
0	5.5	1.18	1.8%	8%	1.53	1350	S-27-½-A	
	6.6	1.18	1.5%	8%	1.53	1350	S-27-½-A	
	7.5	1.18	3.0%	8%	1.53	1350	S-27-½-A	
	3.5	1.17	3.0%	8%	1.52	1350	S-35-C	
	4.0	1.16	2.5%	8%	1.51	1350	S-35-C	
80	5.5	1.41	1.8%	8%	1.48	1350	S-35-C	
	6.6	1.11	1.5%	8%	1.44	1350	S-35-C	
	7.5	1.09	3.0%	8%	1.42	1350	S-35-C	
	4.0	1.14	2.5%	8%	1.48	1350	S-35-C	
100	5.5	1.12	1.8%	8%	1.45	1350	S-35-C	
	6.6	1.08	3.0%	8%	1.40	1350	S-35-C	
	4.0	1.13	2.5%	8%	1.47	1350	S-40-B	
200	5.5	1.10	1.8%	8%	1.43	1350	S-40-B	
	6.6	1.05	1.5%	8%	1.36	1350	S-40-B	
	7.5	1.03	3.0%	8%	1.34	1350	S-40-B	
	4.0	1.13	2.5%	8%	1.47	1350		G-64-A
350	5.5	1.10	1.8%	8%	1.43	1350		G-64-A
	6.6	1.05	3.0%	8%	1.36	1350		G-64-A

*Upon notice from the manufacturer, the rated initial mean horizontal and the equivalent mean spherical watts per candle may be changed to diminish any or all of the figures shown; the lamps at such efficiencies shall conform to the initial limits and life performance specified above.

Respectfully submitted,
Committee on Specifications,
J. R. Sloan, Chairman.
Sub-Committee on Incandescent Lamp Specifications.
J. L. Minick, Chairman.
L. S. Bilau,
Henry Schroeder,
B. F. Fisher, Jr.
C. W. Bender.

REPORT OF COMMITTEE ON WIRE SPECIFICATIONS.

Your Committee on Wire Specifications presents the attached specifications for bare conductors and insulated conductors for potentials up to 750 volts. The Committee has availed itself of the following work by outside Associations:

1. Terminology of Electric Conductors based largely upon recommendations of the Bureau of Standards.

2. Copper specifications of the American Society for Testing Materials.

3. Rubber Specifications and Method of Analysis of the Committee appointed by the New York Rubber Conference of December 7th, 1911.

The specifications are made in two parts. The first consists of Specification Forms with places for briefly filling out practically every characteristic of the wire or cable which is susceptible of tabulation. The second part consists of general specifications for all, the labor and materials entering into the manufacture of wires and cables.

An appendix contains the chemical clauses of a specification for rubber insulation and the procedure for

analysis to be used in connection with the specifications.

The Committee recognizes that various grades of rubber insulation may be used with advantage in railroad work, according to the degree of permanence desired but where great reliability is required, a grade of insulation at least equal to that called for in the following specifications, should be used. The Committee will not undertake to express an opinion on the relative merits of compounds with a dry mineral base, and those containing reclaimed rubber, rubber substitutes or other organic substances.

SPECIFICATIONS.

1. Scope of Specifications:

These specifications are intended to cover all kinds of wire likely to be used for car lighting, shop machinery, lighting of buildings, and general distribution from low tension, (750 volt maximum) power buses. No attempt is made to cover cables for high tension transmission.

2. Terminology:

The following terminology is based upon a study of this subject by the Bureau of Standards, and upon a canvass of wire manufacturers and users made by a member of this Committee. The Standards Committee of the A. I. E. E., also has the subject under consideration, and when their report is issued, it should supersede the following:

Definitions.

(a) **Wire:** A slender rod or filament of metal.

Remarks.

The definition restricts the term to what would ordinarily be understood by the term solid wire. The word "slender" is used in the general sense of long in comparison with the diameter. If the wire is covered with insulation, it is properly called an insulated wire; while primarily the term **wire** refers to the metal, nevertheless when the context shows that the wire is insulated the term wire will be understood to include the insulation.

(b) **Conductor:** A wire or combination of wires not insulated from one another, suitable for carrying a single electric current.

The term **conductor** is not to include a combination of conductors insulated from one another, which would be suitable for carrying several different electric currents.

Rolled conductors (such as busbars) are, of course, conductors but are not considered under the terminology here given.

(c) **Stranded Conductors.** A conductor composed of a group of wires or any combination of groups of wires.

The wires in a stranded conductor are usually twisted or braided together.

(d) **Cable:** (1) A stranded conductor, (single-conductor cable); or (2) a combination of conductors insulated from one another, (multiple-conductor cable).

The component conductors of the second kind of cable may be either solid or stranded, and this kind of cable may or may not have a common insulating covering. The first kind of cable is a single conductor, while the second kind is a group of several **conductors.** The term **cable** is applied by some manufacturers to a solid wire, heavily insulated and lead-covered; this usage arises from the manner of the insulation, but such a conductor is not included under this definition of "cable." The term "cable" is a general one but in practice it is usually applied only to the larger sizes. A small cable is called a "stranded wire" or a "cord," both of which are defined below. Cables may be bare or insulated, and the latter may be armored with lead or with steel wires or bands. In all cases a cable is a complete conductor, not a part of one.

(e) **Strand:** One of the wires or groups of wires of any stranded conductor.

The majority of American copper wire manufacturers use the word strand to designate a group of bare wires twisted together.

(f) **Stranded Wire:** A group of small wires used as a single wire.

There is no sharp dividing line of size between a "stranded wire" and a "cable." If used as a wire, for example, in winding inductance coils or magnets, it is called a stranded wire and not a cable. If it is substantially insulated, it is called not a stranded wire, but a "cord" defined below.

(g) **Cord:** A small cable, very flexible and substantially insulated to withstand wear.

There is no sharp dividing line between a "cord" and a "cable," and likewise no sharp dividing line in respect to the character of insulation between a "cord" and a "stranded wire."

(h) **Concentric Strand:** A strand composed of a central core surrounded by one or more layers of helically laid wires or groups of wires.

(i) **Concentric Lay Cable:** A concentric strand used as a completed cable.

(j) **Concentric Rope Lay Cable:** A cable composed of a central core surrounded by one or more layers of helically laid groups of wires.

This is a special case of the concentric lay cable just defined.

(k) **N-Conductor Cable:** A combination of N conductors insulated from one another.

It is not intended that the name as here given be actually used. One would instead speak of a 3-conductor cable, a 12-conductor cable, etc. In referring to the general case, one may speak of a "multiple-conductor cable."

(l) **N-Conductor Concentric Cable: A** cable composed of an insulated central conducting core with (N-1) tubular stranded conductors laid over it concentrically and separated by layers of insulation.

Usually only 2-conductor or 3-conductor. Such conductors are used in carrying alternating currents. The remarks on the expression "N-Conductor" given for the preceding definition applies here also.

(m) **Duplex Cable:** Two insulated single-conductor cables twisted together having a common covering.

The term duplex is used by some manufacturers to describe twin cable.

(n) **Twin Cable:** Two insulated single-conductor cables laid parallel, having a common covering.

(o) **Duplex Wire:** Two small insulated conductors twisted together, having a common covering.

(p) **Twin Wire:** Two small insulated conductors laid parallel, having a common covering.

(q) **Twisted Pair:** Two small insulated conductors twisted together without a common covering.

The two conductors of a "twisted pair" are usually substantially insulated, so that the combination is a special case of a "cord."

(r) **Triplex Cable:** Three insulated single-conductor cables twisted together having a common covering.

3. Form of Specifications:

The following forms are recommended for wire and cable specifications as they minimize the chance of accidental omission on the part of the purchaser and manufacturer, and save time for the bidder.

4. Specification Form for Bare Conductor:

Specification No.....
Title.....
Date.....

(Items opposite x need not be specified unless they are to be special as standards for them are given in the General Wire Specifications of the A. R. E. E.)

Material of conductors (Hard or semi-hard, soft drawn copper, or aluminum) .....
Material of Core (semi-hard or hard drawn copper) ....
Stranding (concentric lay or concentric rope lay) .....
xNumber of strands in conductor .....
Number of wires in strand (if rope laid) .....
(Extra flexible conductors shall be specified in terms of the number of wires of a regular A. W. G. size).
Total area in circular mils or equivalent A. W. G. gauge number of conductor .....
Wire [shall / shall not] be tinned.....
Size of each wire, A. W. G. (if extra flexible.....
Length (each piece) (Maximum .....
Length (each piece) (Minimum .....
Whether to be supplied in coils or on reels .....

All workmanship and materials shall conform with the General Wire Specification of the Association of Railway Electrical Engineers.

5. **Specification Form for Insulated Conductor:**

Specification No.....
Title.....
Date.....

(Items opposite x need not be specified unless they are to be special as standards for them are given in the General Wire Specifications of the A. R. E. E.)

Number of separately insulated conductors.....
xMaterial of conductors, (hard of soft-drawn copper or aluminum) .....
xType of stranding, (concentric, rope or special lay)...
x Number of strands in conductor .....
Number of wires in strand, (if rope laid) .....
(Extra flexible conductors shall be specified in terms of the number of wires of a regular A. W. G. size).
Total area of conductor, Circ. mils, or equivalent A. W. G. .....
Size of each wire, A. W. G. (if extra flexible) .....
Wire (shall) be tinned.....
Wire (shall not) be tinned.....
Type of Separator, (if any, ...
Insulation material (each conductor .....
Insulation material (belt .....
x Minimum thickness of insulation (each conductor..
Minimum thickness of insulation (belt .....
x Tape, material .....
(each conductor .....
Number of tapes (over each layer .....
(over all .....
(size .....
Pressure wire, (if any) (location .....
(insulation .....
Servings, material .....
Servings, number .....
Servings, thickness of each, inches.....
x Braid, material .....
x Braid, number on each conductor .....
x Braid, number over all .....
Tracers, (if required), material .....
Tracers, (if required), number .....
Tracers, (if required), arrangement .....
Laterals, (if required), material .....
Filling under sheath .....
x Sheath .....
x Thickness of sheath, 64th inch .....
x Filling between sheath and armor, (material .....
x Filling between sheath and armor, (thickness measured .....
x Filling between sheath and armor, (after armoring
x Armor, material and wire or band .....
x Jute over armor (specify if not wanted) .....
Maximum over all diameter (if limit is necessary) ...
Length (each piece) (Maximum .....
(Minimum .....
Whether to be supplied in coils or on reels .....

All workmanship and materials shall conform with the General Wire Specifications of the Association of Railway Electrical Engineers.

6. **General Specifications:**

The following general specifications are to be used in conjunction with the above specification forms.

7. **General Clauses**

(a) All workmanship and materials shall be the best of their respective kinds and shall be in full accord with the best modern engineering practice.

(b) The wire or cable shall be open for inspection by an authorized representative of the Purchaser, who shall be afforded all necessary facilities to assure him that the materials used, and the process of manufacture, conform with the specifications. The braid or sheath shall not be applied until the inspector has approved (in writing) the insulation.

(c) The Contractor shall notify the designated representative of the Purchaser sufficiently in advance of the completion of the wire or cable to enable inspection to be arranged for.

(d) The manufacturer shall furnish suitable apparatus and shall make the tests in the presence of the Railroad Company's representative who shall be allowed every reasonable fiacility to assure himself that the requirements of this specification have been complied with, except that when chemical analysis of the rubber insulation is required, it shall be made by the purchaser.

(e) The combined area of the wires when laid out straight and measured at right angles to their axes shall be not less than the specified gauge or circular mils. Unless otherwise specified, conductors shall be of soft-drawn copper.

(f) Unless otherwise specified, the thickness of insulation shall be the minimum allowed by the National Board of Fire Underwriters, for 600 volts.

(g) Unless otherwise specified, the stranding shall be concentric and in accordance with the following table:

TABLE 1.

Range of Sizes.	Minimum Number of Wires in Conductor.
2,000,000—1,600,000 Circ. Mils.	127
1,500,000—1,100,000	91
1,000,000— 550,000	61
500,000— 250,000	37
No. 0000—No. 1 A. W. G.	19
2— 8	7
Smaller Sizes	1

The following stranding is recommended for extra-flexible conductors.

TABLE II.

Approximate Size, A. W. G.	Number of Wires of Standard A. W. G. Gauge in Conductor.
0000—00	127
0— 1	91
2— 6	61
8—14	37

(h) If exigencies of manufacture require repairs or joints in the insulation, the work shall be done in such a way as to leave the repaired part or joint and all parts effected by it, as strong and durable electrically as the remainder of the insulation. In the case of rubber insulation, patches and joints shall be properly vulcanized.

8. **Electrical Tests:**

(a) **High Potential Test:** The high potential test voltage shall be applied for five (5) minutes; shall have a frequency not exceeding one-hundred (100) cycles per second and shall approximate as closely as possible to a sine-wave. The source of energy shall be of ample capacity.

TABLE III.

TEST POTENTIALS, KILOVOLTS.

5 Minute Tests.

Rubber, use 100% of following potentials.
Varnished Cloth, use 100% of following potentials.
Impregnated Paper, use 75 % of following potentials.

Size of Conductors.	Thickness of Insulation, 64ths Inch.								
	2	3	4	5	6	7	8	10	12
18 A.W.G	1.0	2.5	4.5	5.5	6.5	7.5	8.5	10.5	12.5
16	1.0	2.5	4.5	5.5	6.5	7.5	8.5	10.5	12.5
14		2.5	5.0	6.0	7.0	8.0	9.0	11.0	13.0
12		2.5	5.0	6.0	7.5	8.5	9.5	11.5	13.5
10		3.0	5.0	6.5	8.0	8.5	10.0	12.0	14.0
8		3.0	5.0	7.0	8.0	9.5	11.0	13.0	15.0
6			5.0	6.5	8.5	10.0	11.5	14.0	16.0
4			4.5	6.5	8.5	10.0	11.5	14.5	17.0
2			4.0	6.0	8.0	10.0	12.0	15.0	18.0
1			4.0	6.0	8.0	10.0	12.0	15.5	18.5
0				5.5	8.0	10.0	12.0	15.5	18.5
00				5.0	7.5	9.5	11.5	15.5	18.0
000				5.0	7.5	9.5	11.5	15.5	19.0
0000				4.5	7.0	9.0	11.5	15.3	19.0
250,000 C.M.				4.0	6.5	9.0	11.0	15.5	19.0
500,000				2.5	5.0	7.5	10.0	14.5	19.0
750,000						6.5	9.0	14.0	18.5
1,000,000						5.5	8.0	13.0	17.5
1,250,000							7.5	12.5	17.5
1,500,000							7.0	12.0	17.0
1,750,000							6.5	11.5	16.5
2,000,000							5.0	10.5	15.5

(For intermediate sizes use the voltages corresponding to the next larger size, having the same thickness of insulation.)

(b) **Insulation Resistance Test:** The insulation resistance shall be measured after the high potential test, and shall be made after a one (1) minute electrification with a battery having an e. m. f. of not less than one hundred (100) and not more than five hundred (500) volts and the results corrected to the standard temperature of sixty (60) degrees Fahrenheit.

TABLE IV.

MEGOHM-MILES AT 60° F. BASED UPON THE CONSTANT 4000.

1 Minute Electrification.

Rubber, minimum shall be 100% of following.

Varnished Cloth, minimum shall be 15% of following.

Impregnated Paper, minimum shall be 12½% of following.

Size of Conductors.	Thickness of Insulation, 64ths Inch.								
	2	3	4	5	6	7	8	10	12
16	1400	1800	2150	2400	2650	2850	3050	3400	3650
18 A.W.G.	1600	2050	2450	2800	3000	3200	3400	3750	4050
14		1550	1850	2150	2350	2550	2650	3050	3350
12		1350	1600	1850	2050	2250	2400	2750	3000
10		1150	1350	1600	1800	2000	2150	2400	2650
8		850	1050	1250	1450	1650	1750	2050	2200
6			850	1050	1200	1350	1450	1750	1950
4			750	850	1000	1150	1250	1450	1650
2			650	750	850	950	1050	1250	1450
1			600	650	750	850	1000	1150	1350
0				600	700	800	950	1050	1200
00				550	650	750	850	950	1050
000				500	600	650	750	850	1000
0000				450	550	600	650	800	950
250,000 C.M.				400	475	575	625	725	875
500,000				300	375	400	475	575	675
750,000						325	400	475	525
1,000,000						300	325	400	475
1,250,000							325	375	425
1,500,000							300	325	400
1,750,000							275	300	375
2,000,000							200	275	325

9. **Copper, Soft, Semi-Hard and Hard Drawn:**

The current issue of the specifications of the American Society for Testing Materials shall be complied with in every respect. Sufficient data on the conductivity of tinned wire not being available, allowance will be made in conductivity by the inspector.

10. **Tinning:**

Tinned wire shall be provided with a heavy uniform coating of commercially pure tin without projections.

Where tinned wire is supplied but not called for, the following test is not required.

Samples of wire, before stranding or covering, shall be thoroughly cleaned with alcohol and immersed in hydrochloric acid or specific gravity 1.088 and temperature 60° F. for one (1) minute. They shall then be rinsed in clear water and immersed in a solution of sodium sulphide of specific gravity 1.142 for thirty (30) seconds and again washed. This operation shall be repeated three (3) times and upon the completion of the fourth cycle, the sample shall show no sign of blackening.

The sodium sulphide solution shall contain an excess of sulphur and shall have sufficient strength to thoroughly blacken a piece of clean untinned copper wire in five (5) seconds.

11. **Separator:**

The separator may consist of soft cotton yarn, (which may be braided), or of paper or muslin tape. With untinned conductors, the separator shall completely cover the conductors; with tinned conductors, it is desirable that the separator shall allow the insulation sufficient contact with the conductor to prevent the conductor sliding in the insulation.

12. **Rubber Insulation (with Mineral Base):**

(a) **Limits:** The compound shall conform in chemical limits and specific gravity with the requirements of the Committee appointed by the Rubber Conference of December 7th, 1911, New York. (See Appendix).

(b) **Concentric** Application: The compound shall be applied concentrically about conductor and shall fit tightly thereto. The conductor shall be tinned. If necessary, in order to achieve this result on insulated conductors of greater diameter than three-eights (⅜) of an inch over the insulation, a tape shall be applied over the insulation before vulcanization. Such tape, if it does not comply with the tape specification given hereinafter, will be additional to any which may be required in the accompanying wire specification form.

(c) **Tensile Strength and Elongation:** A sample which may be of entire, segmental, or approximately rectangular cross-section, at the discretion of the manufacturer, shall be cut from the insulated conductor by means of a sharp knife. The sample shall be bent in very direction to magnify and reveal any surface incision or imperfection which may exist. A portion of the sample without such defects and having a free length of not less than two (2) inches shall then be stretched at the rate of twelve (12) inches per minute, until it breaks. The marks shall be placed on the insulation before its removal from the conductor. Five (5) samples from every 25,000 ft. or less, shall be tested in this way. Tensile strength and elongation tests shall be made on unstretched samples.

Then compound shall conform to the following limits:

TABLE V.

Property.	Maximum	Minimum
Tensile strength, lbs. per sq. in. (each sample).	—	1000.
Elongation in two (2) in. length at break (times original length)	—	5
Elongation 5 seconds after release, when stretched at the rate of 12 in. per minute to 3 times its length	20%	—

(d) **Electrical Tests:** Electrical tests shall be made upon all wire or cable after at least twenty-four (24) hours immersion in water while still immersed and before the application of any covering other than the tape or braid used in vulcanization. The insulated conductor shall successfully meet the high potential tests specified in Table III. In the case of rubber insulated multiplex cables, the insulation resistance shall be measured be-

fore assembling the conductors. An additional electrical test shall be made on lead covered cable only and shall consist of a high potential test to be made upon the cable after assembling and leading and without immersion in water. In the case of multiplex cables, this test shall be made successively between each conductor and the other conductors and sheath.

The insulation resistance shall be not less than is given in Table IV.

The insulation resistance (megohms) at a given temperature shall be reduced to that at 60 deg. Fahr. by dividing by the co-efficient in Table VI corresponding to that temperature.

TABLE VI.

(Tests shall be made at temperatures within the scope of this table).

Temperature Degrees Fahr.	Coefficient shall not be greater than	Temperature Degrees Fahr.	Coefficient shall not be less than
46	1.44	60	1.000
47	1.41	61	.974
48	1.37	62	.949
49	1.34	63	.925
50	1.30	64	.901
51	1.27	65	.878
52	1.24	66	.855
53	1.20	67	.833
54	1.17	68	.812
55	1.14	69	.791
56	1.11	70	.771
57	1.09	71	.751
58	1.06	72	.732
59	1.03	73	.713
60	1.00	74	.695
..	....	75	.677

13. **Varnished Cloth Insulation:**

(a) **Description:** The insulation shall consist of a closely woven cotton cloth and a viscous filler. Each surface of the cloth shall have smooth continuous films of varnish and shall be free from wrinkles, blisters, and all other imperfections. It shall be thoroughly impregnated with insulating compound, shall be pliable and shall have no tendency to crack when doubled on itself.

(b) **Filler:** The filler shall be a viscous moisture-repelling insulating compound whose dielectric constant is similar to that of the varnished cloth insulation and of such a nature that it will prevent the tapes from unwrapping when cut, but will allow the layers to slide upon each other when the cable is bent.

(c) **Assembly:** The insulating cloth shall be applied in the form of tape wound on spirally and reversed at least every two layers. The tapes shall be of such widths that for different diameters of cable they will lie smoothly and be free from wrinkles; the turns shall overlap and the joints in successive layers be staggered. The filler shall be so applied between layers as to exclude all air, the whole forming a hard semi-flexible wall of insulation.

(d) **Tape:** A layer of cloth tape thoroughly filled with a rubber compound lapping one-fourth of its width shall be applied over the cloth insulation.

(e) **Electrical Tests:** Each and every length of cable shall conform to the specified electrical tests. Braided wires to be tested after twelve (12) hours immersion in water and before the braid is applied; lead covered conductors to be tested against the sheath with sheath grounded. Multiplex cables shall be tested between each conductor and the other conductors and sheath or ground in multiple.

14. **Impregnated Paper Insulation:**

(a) **Description:** The insulation shall consist of a Manila paper applied helically and evenly to the conductor, and then thoroughly impregnated with an insulating compound. The cable shall be pliable and show no tendency to harden injuriously at 32° F. The pacer or compound shall contain no free acids or free alkalis. The compound shall be applied so as to exclude all air and moisture.

(b) **Tensile Strength:** The tensile strength of the paper measured lengthwise before impregnation shall be equivalent to the weight of a strip not less than 20,000 feet long, and its elongation shall be not less than two (2) per cent. in a length of two (2) inches. Acceptance will be based upon the average of six (6) tests on samples selected at random from every order.

(c) **Electrical Tests:** Each and everry length of cable shall conform to the specified electrical tests. No immersion is required before testing. The potential test to be made between conductor and sheath with the sheath grounded. Multiplex cables shall be tested between each conductor, and the other conductors and sheath or ground in multiple.

15. **Braids.**

(a) **Description:** Braid shall be of closely woven cotton thread, at least two-ply, thoroughly impregnated with an insulating weatherproof compound and finished with a black insulating compound thoroughly slicked down. The compound shall be neither injuriously affected by nor have injurious effect upon the braid at a temperature of 200° F. The thickness shall be not less than given in the following table.

TABLE VII.

Diameter Over the Insulation, Inches.	Thickness of Braid, Inches, not less than.
.160	.018
.290	.028
.530	.038
1.000 and over	.053

For intermediate diameters use next smaller diameter.

NOTE:—The above does not apply to fancy or special braids for fixtures, etc.

(b) **Tests:** A six inch sample of wire with carefully paraffined ends shall be weighed and submerged in fresh water of a temperature of 70 degrees F. for a period of twenty-four hours. The increase in weight after submersion and removal of surface water shall be not more than 9 per cent. of the weight exclusive of copper and insulation before submersion. The compound shall not drip at a temperature of 125° F.

16. **Rubber Filled Cloth Tape:**

The tape shall consist of a cotton cloth not lighter than one (1) pound per four (4) yards 36" wide with not less than 56x60 picks per inch, thoroughly filled with a rubber compound. The tape shall be applied spirally overlapping not less than one-quarter of its width. The following table gives the maximum width of tape allowed.

TABLE VIII.

Diameter Over Insulation, Inches.	Maximum Width of Tape.
2.00	5"
1.75	4–½"
1.50	4"
1.25	3–½"
1.15	3–¼"
1.00	3"
.88	2–¾"
.75	2–⅜"
.62	2"
.50	1–¾"
.44	1–½"
.38	1–⅜"
.31	1–⅛"
.25	⅞"
.19	¾"
.16	⅝"

For intermediate diameters use next smaller diameter.

17. **Sheath:**

(a) **Thickness:** Unless otherwise specified the sheath shall have an average thickness of not less than that indicated in the tabulation next following, and the minimum thickness shall in no place be less than ninety (90) per cent. of the required average thickness.

TABLE IX.

Diam. of Core, Inches.	Corresponding Thickness of Sheath in Inches. Paper Insulation.	Rubber or Var. Cloth Insulation.
—0.29	5/64	4/64
0.30—0.69	6/64	5/64
0.70—1.24	7/64	6/64
1.25—1.99	8/64	7/64
2.00—2.69	9/64	8/64
2.70—over	10/64	9/64

For intermediate diameter use next smaller diameter.

(b) **Composition:** The sheath shall consist of commercially pure lead for all cables having a core diameter (i. o. internal diameter of the sheath) less than two inches; for cables having a core diameter equal to two (2) inches or more the sheath shall consist of an alloy of lead and commercially pure tin containing not less than one (1) per cent of tin.

18. **Wire Armor:**

If the cable is rubber insulated, it shall be covered with tape, braid, or other suitable protection before passing through the asphalt compound.

(a) **Armor:** The core of the cable shall be run through a hot asphalt compound, served with a layer of jute yarn, run through hot asphalt again, and then laid with galvanized wire armor.

(b) **Size of Wire:** The porper size of armor wire will depend upon the conditions of service; the latitude allowed in the following table represents the difference arising from such difference in service conditions. Unless otherwise specified, the armor wire shall be the minimum size.

TABLE X.

Diameter of Cable Under Jute Bedding, Inches.	Armor Wire A.(Steel)W.G.	Jute Bedding Under Armor. Measured in Finished Cable, Inches.
0.00—0.50	14—13	2/32 minimum
0.44—0.69	12	2/32
0.63—1.00	10	2/32
0.88—1.50	8	2/32
1.25—2.00	6	2/32
1.30—larger	4	2/32

(c) **Lay:** The armor shall be applied closely without appreciable space between adjacent wires. The lay shall be from eight to twelve times the pitch diameter.

(d) **Finish:** The armored cable shall be run through hot asphalt compound, served with a layer of the best three-ply 14 lb. hard twisted jute yarn applied in a close short lay, run through hot aspalt compound, then served with a second layer of three-ply, 14 lb. jute yard, run through hot asphalt compound and finally run through some material to prevent sticking.

(Under certain conditions, the purchaser may find it advisable to specify the omission of the outer jute covering).

(e) **Direction of Lay:** Successive layers of jute or jute and armor shall be laid in opposite directions. In the case of multiple conductor cable armored without lead, the outside layer of conductors shall be put on with a right hand lay. The armor shall be put on with a left hand lay.

(f) **Definition of Lay:** The direction of lay is defined as the lateral direction in which the wires run over the top of the cable as they recede from an observer looking along the axis of the cable.

(g) **Armor Wire:** The armor wire shall consist of a galvanized mild steel wire of uniform diameter, free from all cracks, splits or other flaws. Samples shall be taken (at random) from ten per cent of the coils to be used, for each of the following tests. At least eighty per cent of the samples shall fulfill the conditions of the tests in order that the whole lot may be considered satisfactory.

(h) **Tensile Test:** The wire must have a tensile strength of fifty-thousand (50,000) pounds per square inch and an elongation of not less than ten per cent (10%) in eight inches.

(i) **Galvanizing Test:** Thoroughly clean a sample to remove all dirt and grease, rinse in clean water and wipe dry with a clean cloth or cotton waste. Immerse for one minute in a solution of copper sulphate, rinse in clean water and wipe dry. Repeat this operation until the samples have been immersed four times. After these immersions no sample shall show any bright deposit of copper. The samples shall be approximately straight and the ends protected with paraffin. The solution shall be saturated with copper sulphate at 60° F. to which an excess of C. P. cupric oxide has been added and shall be maintained at 60°-65° F. during the test.

(j) **Flexibility Test:** The armor wire shall admit of bending around a spindle of ten times the diameter of the wire and back again without developing cracks of the galvanizing which are visible to the naked eye.

19. **Steel Tape Armor:**

(a) **Description:** The core of the cable shall be run through a bath of hot asphalt compound, served with a layer of jute yarn, spun on with a close short lay, run through hot asphalt compound, armored with a steel tape; armored with second steel tape; run through hot asphalt compound, served with a layer of one hundred pound jute yarn without a close short lay, run through hot asphalt compound and finished by running through some material to prevent sticking. If the cable is rubber insulated, it shall be covered with tape, braid, or other suitable protection before passing through the asphalt compound. Each layer of jute shall be applied in the reverse direction to the adjacent layer. The space between adjacent turns of steel tape shall not exceed one-tenth (1/10) the width of the steel tape.

(b) **Armor Tape:** The tape and jute under armor, after armoring, shall conform to the following table:

TABLE XI.

Cable Diameter Before Armoring, Inches.	Maximum Width Steel Tape, Inches.	Minimum Thickness Each Tape, Inches.	Minimum Thickness Under Armor, Inches.
—0.45	½	0.02	0.06
0.46—0.75	¾	0.02	0.06
0.76—1.00	1	0.03	0.07
1.01—1.40	1-¼	0.03	0.07
1.41—1.70	1-½	0.04	0.08
1.71—2.00	1-¾	0.04	0.08
2.01—over	2	0.05	0.09

20. **Cable Reels:**

(a) **General:** Each reel shall consist of a wooden drum with wooden discs or heads securely fastened thereto.

(b) **Bushings:** Each disc or head of the reel shall be provided with an iron plate or cast iron bushing in the center of which shall be a hole two and one-half (2½) inches in diameter. The plates or bushings

shall be secured to the head by means of bolts or lags through the head.

(c) **Covering:** Insulated cable shall be thoroughly covered with burlap before lagging is applied.

(d) **Lagging:** When used for insulated cable the reels shall be suitably lagged; when used for bare cable, the lagging of the reel shall be replaced by a burlap covering securely bound to the cable.

(e) **Chocking** Reels shall be properly chocked in the car so that there shall be no movement of reels during transit.

APPENDIX.

The recommendations of the Committee appointed by the New York Rubber Conference of Dec. 7th, 1911, to be added when that Committee has presented its report.

Mr. F. J. White takes exception to clause 12-(a), 12-(b), and 12-(d). Mr. T. D. Waring takes exception to tables III and IV.

Committee on Specifications:

J. R. Sloan, Chairman.

Sub-Committee on Wire Specifications:

W. A. Del Mar, Chairman.

A. Ames,
A. L. Crater,
W. S. Clark,
J. H. Davis,
B. W. Kline,
W. I. Middleton,
G. G. Milne,
H. B. Rodman,
R. C. Shaal,
T. D. Waring,
F. S. White,
E. L. Willson.

Report of Committee on Train Lighting Practice

Your committee has endeavored to collect and report on all methods, ways and means of operating electric lighted cars that it thought would aid the members of the association.

Head-End System.

The changing over of head-end systems from 110 volts to 60 volts and advantages of change were covered by this committee last year. Therefore it is sufficient for this committee to report that all the advantages expected by this change have been realized by roads that have changed over (and a step has been gained by this Association in having its recommendations on the adoption of universal voltages accepted by the roads it represents).

Head-End Organization.

It is universal practice to use baggage men and teach them to operate train lighting sets. These men handle all connectors and stock en route and clean up their equipment before arriving at end of run, leaving a complete report of the condition of their train, the generating sets, oil and supplies for train. Also inspections of condition of trains are made by yard men detailed on this work. The B. & O. Ry. employ train electricians who do nothing but electrical work.

Axle Device.

It is necessary to have men devoting all or part of their time on inspecting the following items: Wiring, fans, lamps, fixtures, etc., suspension drive, etc., regulators, dynamos, battery washing, flushing gravity, shop work in yard overhauling dynamos, regulators, fans and parts of equipment. Car shop work, wiring and equipping cars and overhauling parts of equipment on cars going through shops.

In checking over organizations on various roads and comparing them it is not possible to form a universal organization to handle all railroads as the conditions vary a great deal. One road with over 400 cars has about 20 cars per day whereas a road with fewer cars has 40 or 50 cars per day at their largest terminals. The time trains arrive and leave also has its effect on an organization. It has been checked up however that two men can handle 15 cars per day (10 hours) exclusive of batteries and shop work, handling only regulators and dynamos.

It is thought by the committee that the matter of belt fasteners is a subject that deserves some attention and the following deductions made.

That with Crescent Clamps belt breaks behind clamps and is the cause of the large belt loss. Crescent belt clamp are easy, handy and quick to apply, this being the strongest argument in their favor.

Wire lacing wears out and will not run over 3000 miles.

Therefore it is recommended that some of the hinge type of belt fastening devices be given a thorough trial. In trying out these devices the pins and fasteners should be inspected and given the same attention that must now be given to the Crescent Clamp, such as looking out for cracked belts, etc. It is believed if this is done, although a special belt man be put on to do the work and the fastener may cost more, a saving in belt can be made which will more than offset the additional expense.

One difficulty with many of the hinge type of clamps is the fact than one-half of the clamp has to be thrown away whenever the belt is shortened as the clamps are not constructed so they can be removed and used over again. That is particularly true of the steel lace type.

Cleaning Batteries.

Batteries are brought into battery house on trucks, connectors removed and covers are taken off. Steam is used to soften sealing compound and covers, making covers soft as they are less liable to break when removed. They can be laid down on a flat surface and weight placed upon them and all covers will be straight when cool. A wooden hood with a hinge in center and a hole for admitting steam is placed over top of battery tray and steam admitted until covers can be taken out without scraping off sealing compound. A hot iron, chisel shaped, can be used if steam is not available.

Battery house trucks should be as high as benches and acid tanks. Truck is then pulled beside acid tank and acid dumped. One man can do this if tank and truck heights are right. Batteries are then taken to wash-bench and elements removed with a single whip chain tackle with insulated hooks, side and end sheets and porcelain insulating rests removed. Elements are straightened under air pressure, separators adjusted, etc. No water is turned on elements as it makes it hard to standardize acid after battery is re-assembled and it is not recommended by battery manufacturers.

Trays are taken to tray bench, sediment scraped out in boxes or barrels and they are washed out over spray as shown in figure No. 1. Sediment should be kept out of sewer and it is trapped as shown in figure No. 2. Dry sediment is sold for $40.00 per ton. The tanks are then cleaned off with a jet of steam which

removes all corrosion from iron work and frees rollers, dryed with air blast, bottoms of tanks painted and

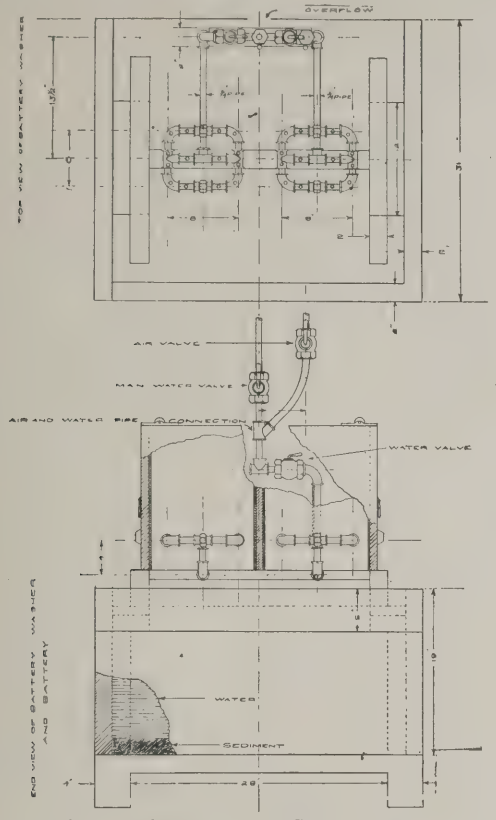


Fig. 2. Diagram of Air Spray Washer.

rollers oiled. Porcelain insulating rests are then put back in tanks, elements replaced and rubber side and end sheets put in (side and end sheets are placed in hot water for a few minutes before applying to make them flexible and less liable to break). Connectors are then applied, acid at 1.225° put in cells and they are charged until acid stops rising for one hour, then discharged and fully charged; watching temperature during charge, connectors removed and acid is then dumped and standardized and replaced (if it is not possible to dump acid to standardize it after cleaning is done, battery should be fully charged before cleaning to drive all acid out of plates, then if elements are not washed in water the acid will be fairly even). Covers are then applied and sealed, compound is poured in hot and smoothed with a hot iron, connectors applied and burnt or tacked with hydrogen flame to insure good contact. Care should be taken to see that all hydrogen gas is out of cells before flame is brought near battery. Cells can be freed from hydrogen gas by blowing them out thoroughly with compressed air or if this is not available batteries should be flushed to nearly the overflowing point to drive this gas out and later syphoned out to the correct height. Tanks are painted and stenciled. It is a good practice to shellac tank before stenciling then the while lead does not turn yellow, shellacing over stenciling after it drys. It is also good practice to use a lead plate tacked on the front of the cell on which the date battery was new and the dates it has been cleaned are stamped with steel stencil. This affords a record which is practically permanent and does not wear out as does the stenciling done with paint.

MANNER OF HANDLING REPORTS ON ELECTRIC LIGHTED CARS.

This committee has given considerable attention and as the number of electric lighted cars increased on the larger roads the present system and forms of reports are becoming cumbersome and taking up a great deal of time, therefore your committee submits a system of reports as follows:

A book form with a carbon copy, original going to Chief Electrician and carbon left in the car for the information of the inspector at the other end of the line. These originals can then be filed in date order in pigeon holes under car number and held for thirty days or longer and afford a ready reference without any copying being done. A card file can also be kept in connection with this book form on which the history of the car can be kept such as the time car was delivered from the car builder, dates car goes in and out of shop, record of accidents to car, dates batteries were changed, dynamo removed for overhauling, equipment failed, etc. This can be kept in a separate card file or in the pigeon hole with the other reports for ready reference. This system has many advantages as it keeps inspectors at opposite ends of the line thoroughly familiar with what work the inspector does at the other end of the run and it is recommended by your committee for adoption.

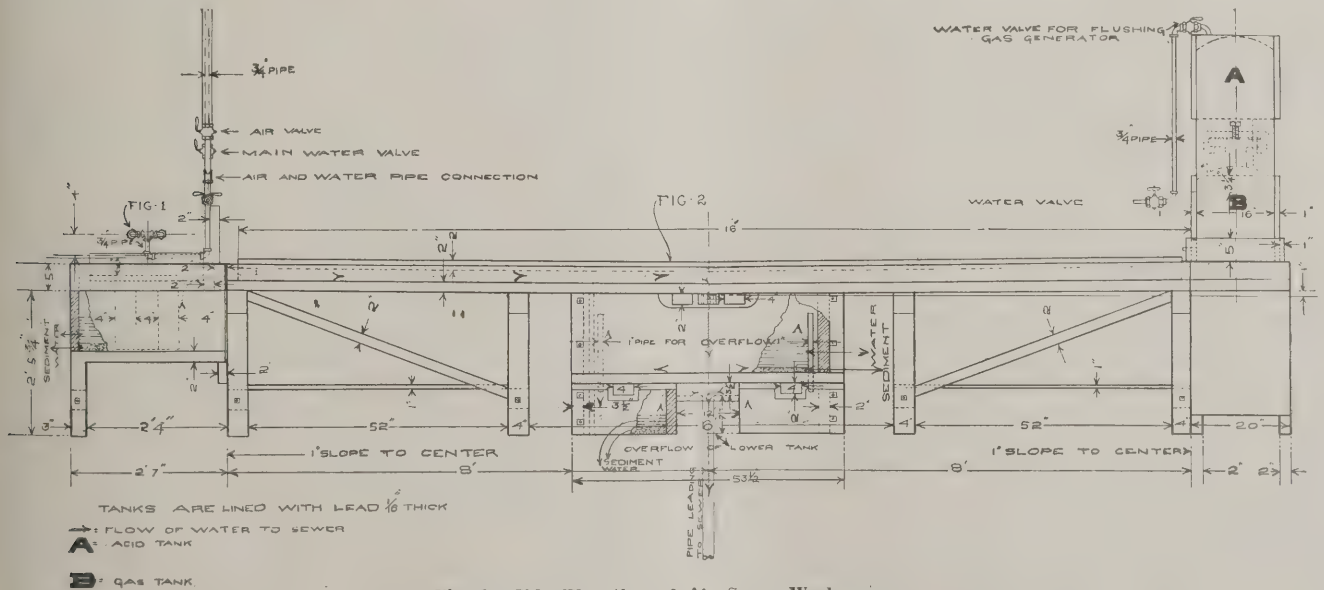


Fig. 2. Side Elevation of Air Spray Washer.

FORM OF INSPECTOR'S REPORT.

Car..... Train In..... Out.....
Place..... Date.....
Apparatus Working.....Lights Fail.....
Sp Gr.....Height of Acid.....
Volts Battery.....Volts Lights.....
Battery Charged.....Hours.....Amps.
Belts..... Train Conn..... Fans.....
Lamps Missing.....Burnt Out.....Applied.....
Oiled Generator.....Cond Eg'pt on Departure.....
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Cause of Failure and Material Used.....
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Signed .....
.....Inspector.

IT IS GOOD PRACTICE TO.

In designing battery box for Edison batteries, arrange it for five cell trays.

Install amp. hour meters with Edison Batteries as there is no definite check on voltage or gravity to indicate state of charge battery is in. (Question for discussion.)

Take gravity readings on pilot cell on lead batteries.

Take voltage of battery and voltage across lamps to check lamp regulator and locate dead cells.

White lead battery trays, it preserves them (question for discussion.)

To avoid use of oak in constructing battery trays (question for discussion.)

Use porcelain skids on battery trays instead of rollers.

Install lamp regulators in all cars on head-end system so that a voltage sufficiently high to charge the batteries enroute can be maintained without straining lamps and in this way do away with yard or terminal charging.

Check train line connectors on daily performance report.

Seal adjustments on regulators.

Use center fixtures for lighting instead of side brackets where possible, parlor and club cars must be given consideration.

Use 5/16" cap screws for securing covers on junction boxes.

Install all conduit on interior of baggage and mail cars.

Have dynamo clearance as follows: 4" between car body and top of generator, 1" between belt and top of end sill and 1½" clearance between brake beam truss rod and axle pulley when brake shoe has worn out and with a wheel which has been turned down to the minimum tire wear.

Have battery and equipment boxes and also steam drips as far away from dynamo as possible so inspectors can get under cars to inspect dynamo easily.

Have steam drips and other drains equipped with suitable shields to keep water and ice off dynamo.

To avoid loss motion in link type dynamo suspensions they should be made of as few pieces as possible.

Secure side irons on link suspensions by putting hook bolts over side irons where they leave end sill of truck to hold them down, otherwise they will pound and break due to crystalizing of iron.

Have dynamo installed on opposite end of car from kitchen.

Have dynamo installed on the front truck of cars running in one direction such as observation cars.

Have specifications on wiring cars, including blue prints of al lockers, junction boxes, battery boxes, wiring diagrams, spacing and location of lamps, etc.

Use dynamo leads made up of No. 30 wires. They are more flexible and test has shown they give better results than leads made up of larger wire.

Give new material and devices on test the same attention that you have to give the material and devices that the tested material would replace, the service of the new apparatus when given this attention may effect a saving.

Use reflectors and shades on all lamps where possible, using steel reflectors in baggage and mail cars.

Use ventilated fixtures to prevent blackening of lamps.

Install four fans in dining cars.

Install exhaust fans or other effective ventilating system in kitchens and smoking compartments of parlor and observation cars.

Use no steel battery boxes unless wood lined. (Question for discussion.)

Keep armature pulleys crowned ¼" (diameter.)

Use as large a dynamo armature pulley as possible. They are easier on belts.

Use flanged axle pulleys. (Question for discussion.)

In spacing and laying out lighting in mail and baggage cars to space lamps for putting in 25 watt lamps so that they by using every other socket 50 watt lamps will give the desired illumination.

Install lamps regulators on inside of cars.

Bush all bearings and wearing parts of dynamo suspensions.

Use stamp metal fuse links in place of copper terminal fuse links. They are better and handier.

Use lamps of standard bulbs and bases and see that fixtures are designed to take standard lamps.

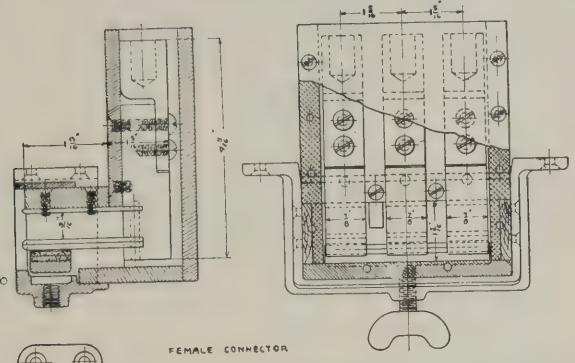
Keep lamps and reflectors clean, they work at a higher efficiency.

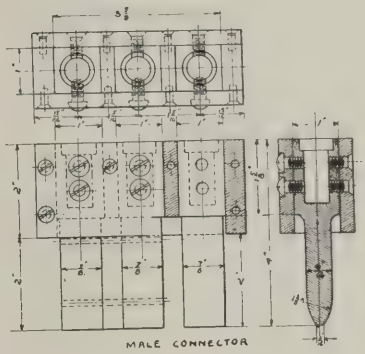
Use yard charging outlet as per figure No. 3.

That part of this paper which is headed "It is good practice to" contains a great many features that have come up on which there is a gerat deal of uncertainty as to the practicability of adoption and it is recommended that such items be discussed and voted on.

F. E. Hutchinson, Chairman.
F. R. Frost,
C. R. Gilman,
Geo. B. Colgrove,
L. S. Billau.

EXHIBITS OF COMMITTEE ON STANDARDS





LOCATION OF CONNECTOR AND ARRANGEMENT OF TERMINALS WHEN FACING CAR.

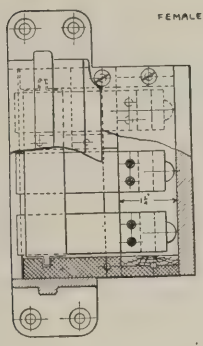


EXHIBIT "A"

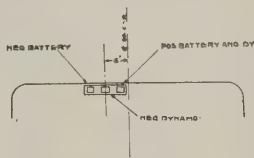

NEG BATTERY
POS BATTERY AND DYNAMO
NEG DYNAMO
NOTE:
IN LEAD AND SYSTEM JUMPER TO BE PLACED ACROSS NEG BATTERY AND NEGATIVE DYNAMO

FIG. 1.

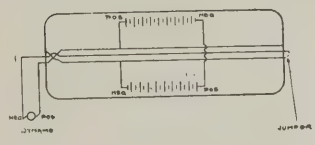
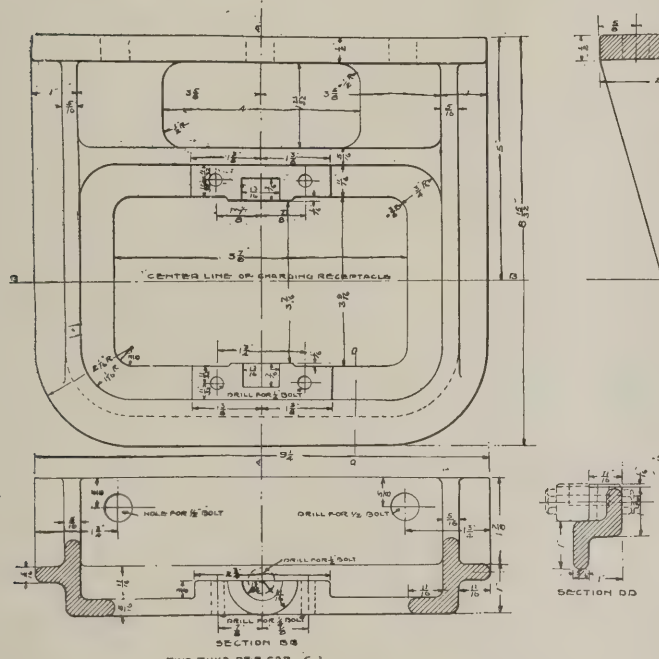
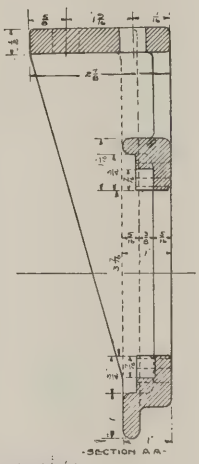
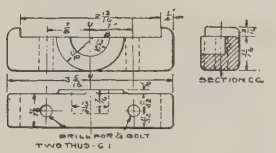


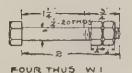
FIG. 2.



TWO THUS PER CAR C. I.







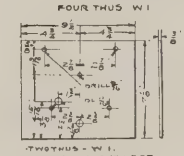
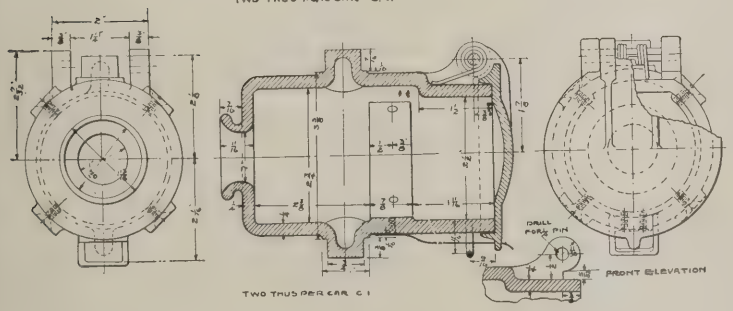
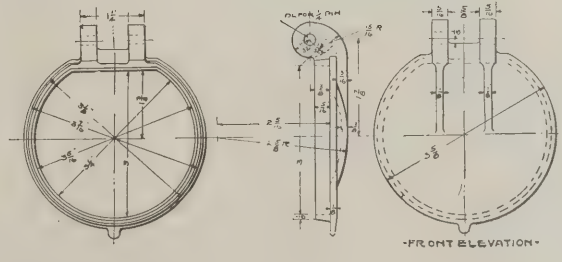


EXHIBIT "B"



TWO THUS PER CAR C I



TWO THUS PER CAR - BRASS

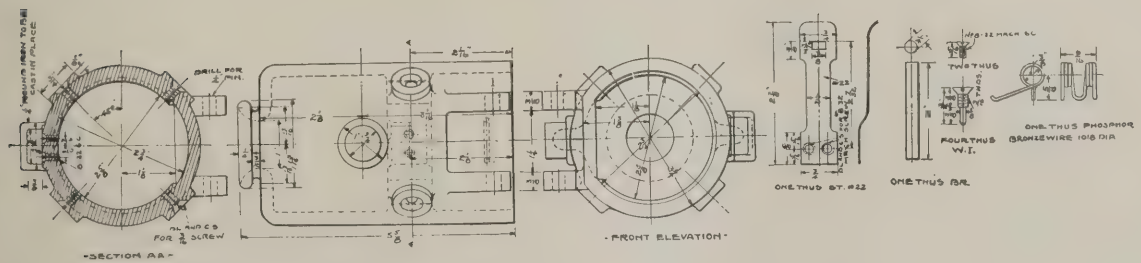
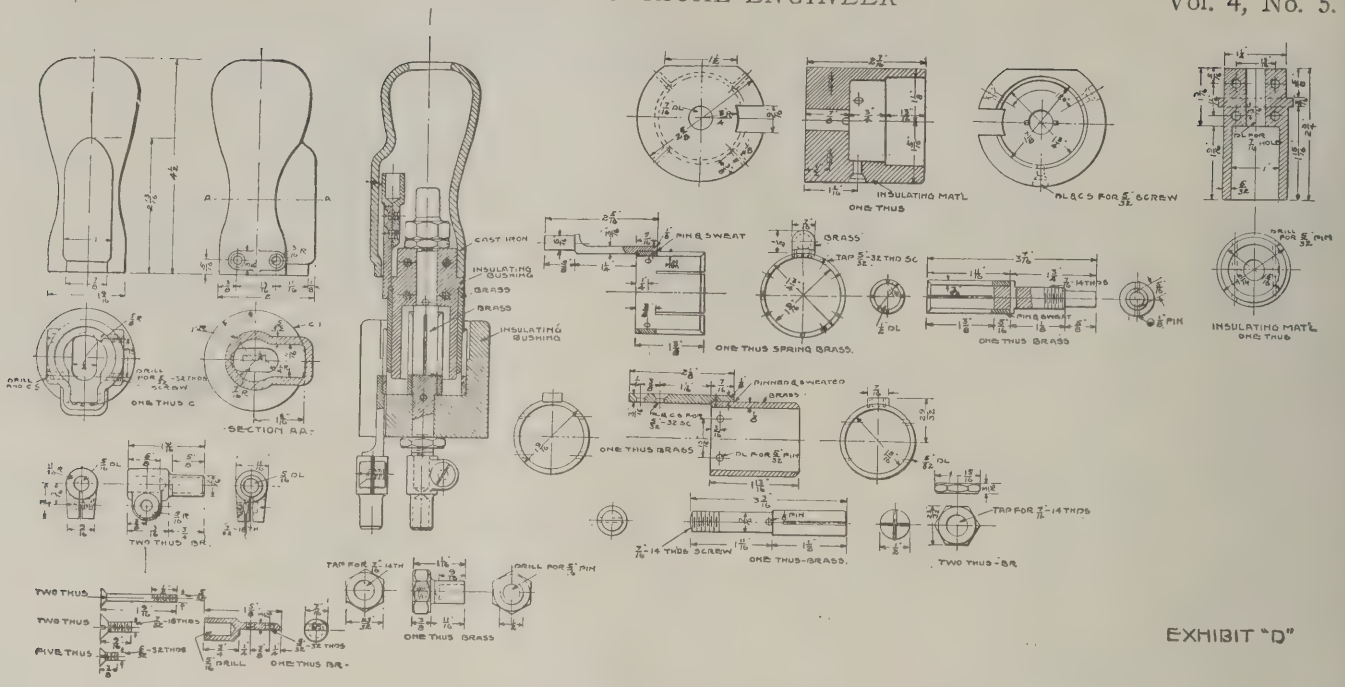
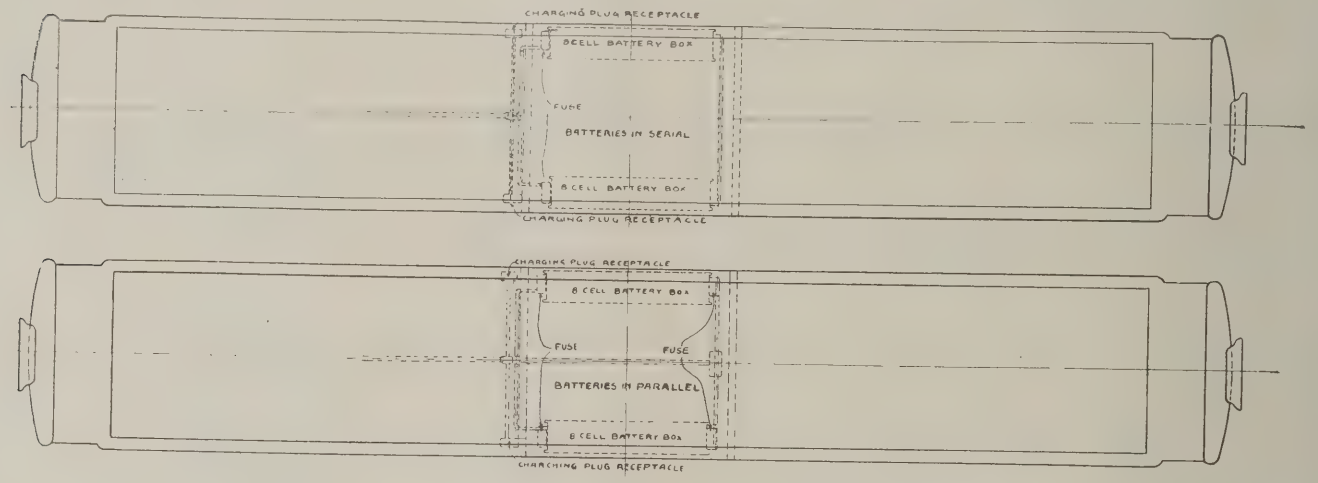
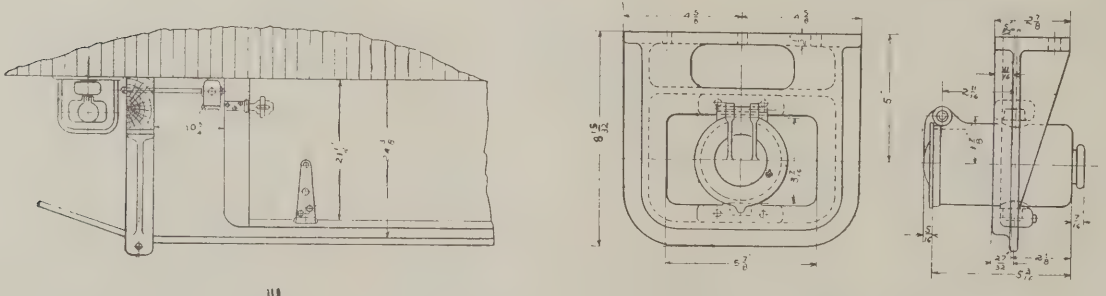


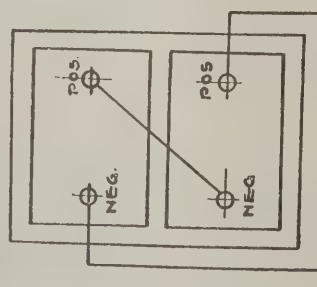
EXHIBIT "C"





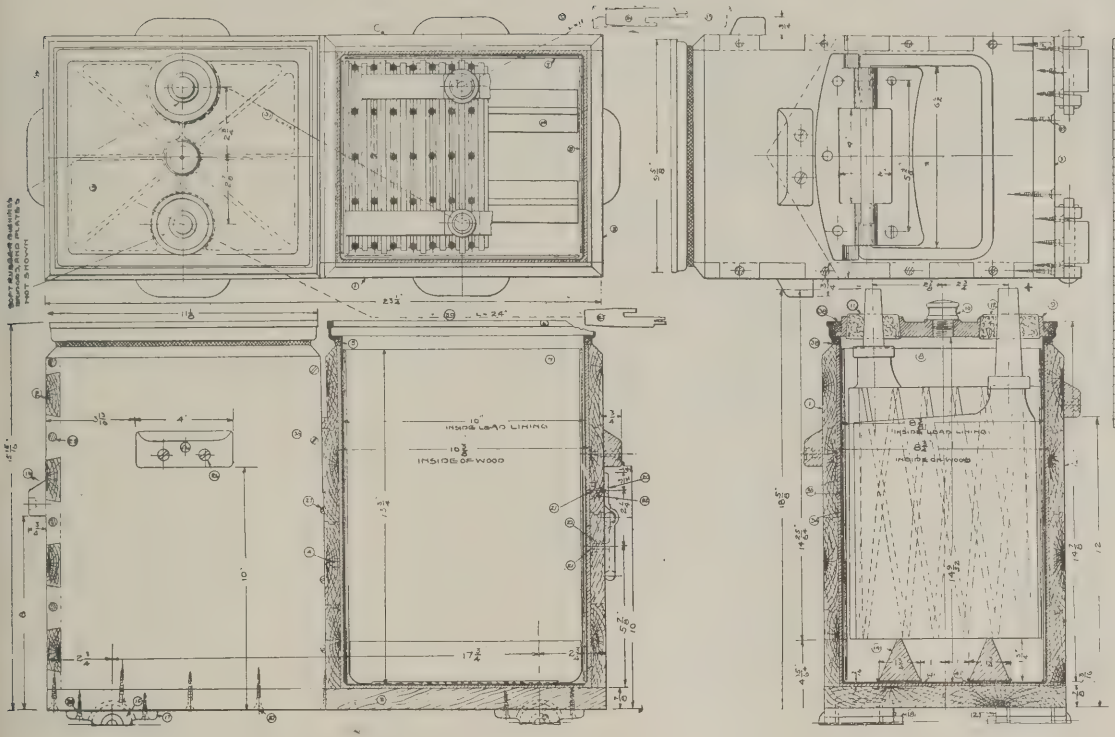


CONNECTION AND ARRANGEMENT OF TERMINALS IN DOUBLE COMPARTMENT TRAY.



NOTE:
WHEN WESTINGHOUSE HAND CONNECTORS ARE USED, MALE HEAD TO BE USED FOR POS. FEMALE HEAD FOR NEG. TERMINAL.

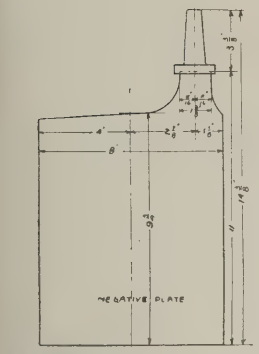
FIG. 3.

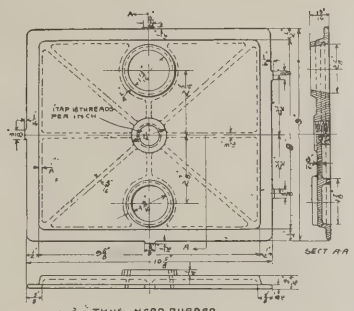


NOS		NAME	MATL
1	2	TANK SIDES	WOOD
	2	ENDS	
3	1	BOTTOM	
4	1	PARTITION	
5	2	4 LBS LEAD LINING	LEAD
6	2	COVER FRAME	
7	4	RUBBER SIDE LINING	HARD RUB
8	4	" END	"
9	2	COVERS	
10	2	VENTS	
11	2	NEGATIVE TERM BUSH	SOFT
12	2	POSITIVE "	"
13		CONNECTOR SLEEVE	
14	4	BOTTOM INSULATORS	PORCELN
15	4	ROLLERS	
16	6	SUPPORTS	
17	4	ROLLER BRACKETS	M I
18	4	" SPINDLE	S Y
19	1	CHEST HANDLE	
20	6	⅜ FILLISTER HD STOVE BOLT	W I
21	10	⅜ NUTS	"
22	6	⅜ WASHERS	
23	4	⅜ COTTER PIN	
24	1	WESTHOUSE CONTOR HALE BRASS	
25	1	STYLE 11887 " PERU	
26	4	10 1/2 RD HEAD WOOD SC	"
27	24	10 1/2 FLAT "	"
28	16	#4-1 "	"
29	24	⅜ x 6 WOOD DOWELS	WOOD
30	1	8 FLEE RC WHEELER	ASSTRAND
31		" "	L W SOLID
32	1	FOLDER	L W ASSTRAND
33		PETROLYTE	
34		PARAFFIN	
35		PAINT	
36		SOLDER HARD	
37		SPECIAL LOWMELTING	
38		SEALING COMPOUND	
39	8	#6-1½ FLATHEAD WOOD SC	BRASS
40	2	CONNECTOR TERMINAL	
41	4	BOTTOM INSULATORS	WOOD
42	2	LEAD TUBING	LEAD

NOTE METHOD OF APPLYING LEAD LININGS
SIZE LEAD TANK WITH ONE COAT OF CHRYSOLITE THEN WITH PETROLYTE. THEN INSERT IN WOODEN TANK WHICH HASBEEN FILLED TO A DEPTH OF 6 WITH A MIXTURE OF PARAFFIN & PETROLYTE HAVING A MELTING POINT OF 150°F
NOTE METHOD OF REMOVING LEAD LININGS. FILL LINING WITH HOT WATER UNTIL PARAFFIN MELTS THEN WITHDRAW LINING.

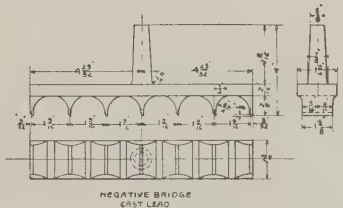
EXHIBIT "G"

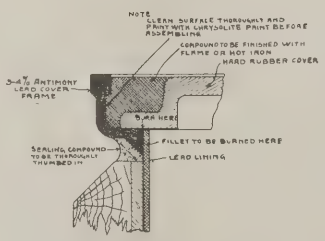




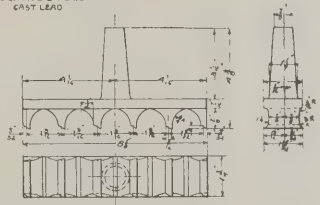
COMPOUND - RUBBER COVER	
PURE PARA RUBBER	18 ¾
RUBBER (SUBSTITUTE)	18 ¾
FINE STOCK	10 "
VUTULE	7 "
RECLAIMED RUBBER (OLD INNER TUBES)	9 "
OLD RUBBER DUST	21 "
SULPHUR	17 "

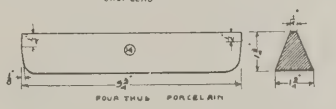
SEALING COMPOUND	
COAL TAR (VISCOUS LIQ.)	17 %
PETROLYTE (MEDIUM)	67 "
LAMP BLACK DRY	16 "

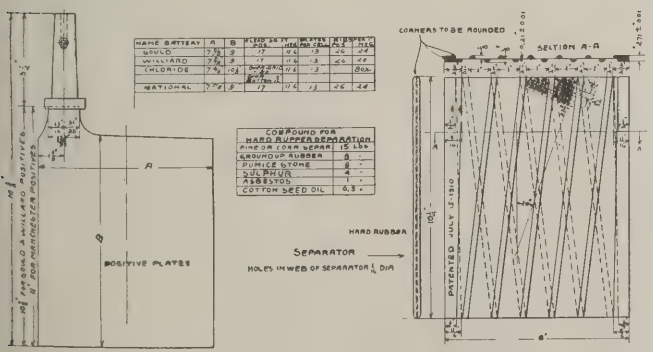



NOTE
CLEAN SURFACE THOROUGHLY AND PAINT WITH CHRYSOLITE PAINT BEFORE ASSEMBLING
COMPOUND TO BE FINISHED WITH FLAME OR HOT IRON
HARD RUBBER COVER
3-4⅜ ANTIMONY LEAD COVER FRAME
SEALING COMPOUND TO BE THOROUGHLY THUMBED IN
FILLET TO BE BURNED HERE
LEAD LINING

SECTION SHOWING METHOD OF SEALING TANK AND COVER







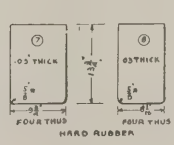


EXHIBIT "H"

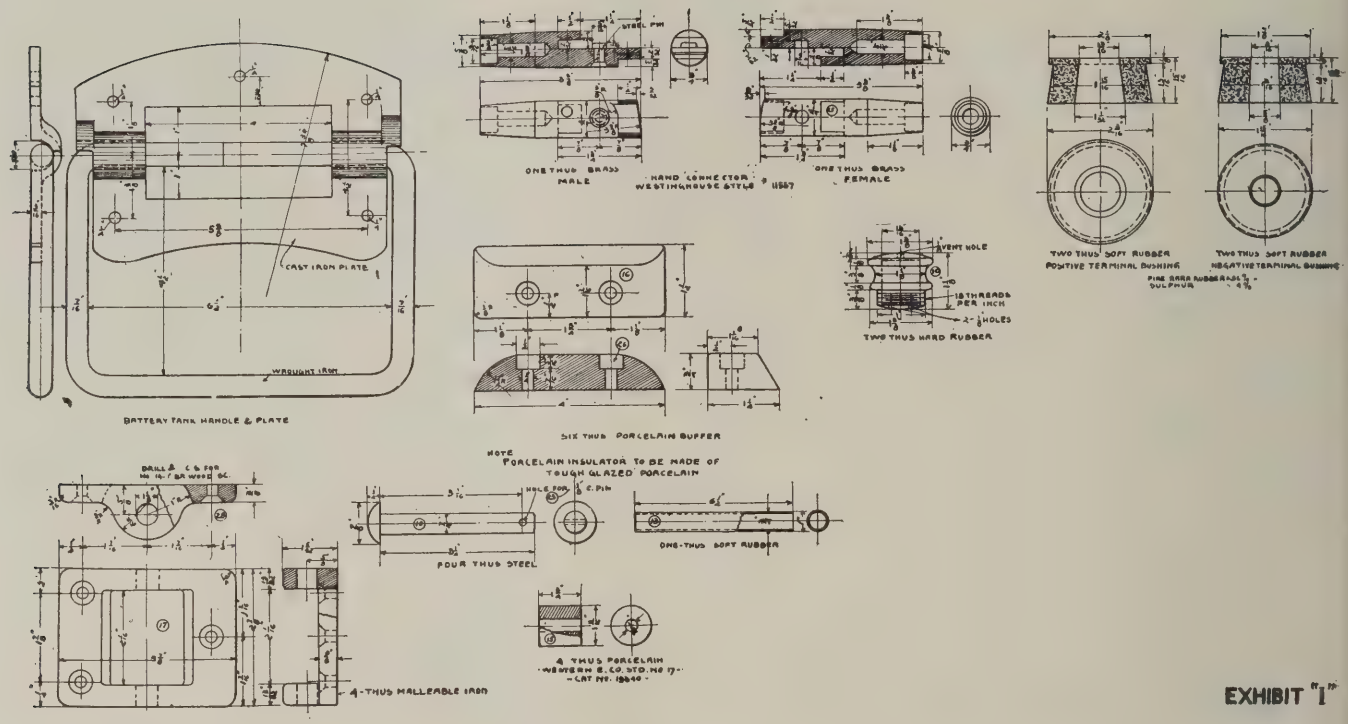

CAST IRON PLATE
WROUGHT IRON
BATTERY TANK HANDLE & PLATE
ONE THUS BRASS MALE
HAND CONNECTOR WESTINGHOUSE STYLE 11587
ONE THUS BRASS FEMALE
TWO THUS SOFT RUBBER POSITIVE TERMINAL BUSHING
TWO THUS SOFT RUBBER NEGATIVE TERMINAL BUSHING
VENT HOLE
TWO THUS HARD RUBBER
SIX THUS PORCELAIN BUFFER
NOTE PORCELAIN INSULATOR TO BE MADE OF TOUGH GLAZED PORCELAIN
FOUR THUS STEEL
ONE-THUS SOFT RUBBER
4 THUS PORCELAIN WESTERN E. CO. STD. NO 17 CAT NO. 18649
4-THUS MALLEABLE IRON

EXHIBIT "I"

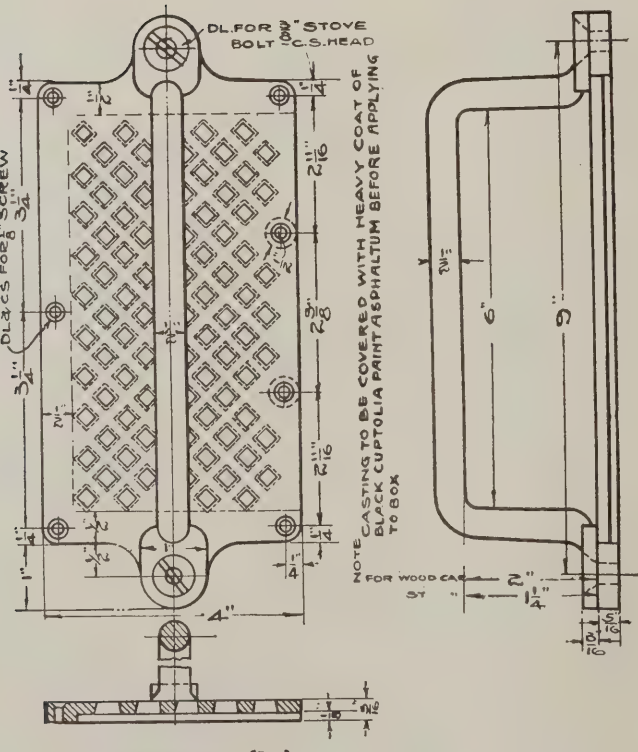

DL FOR 3/8" STOVE BOLT C.S. HEAD
DL & CS FOR 1/8" SCREW
NOTE CASTING TO BE COVERED WITH HEAVY COAT OF BLACK CUPTOLIA PAINT ASPHALTUM BEFORE APPLYING TO BOX
FOR WOOD CAR
ST "

EXHIBIT 'K'

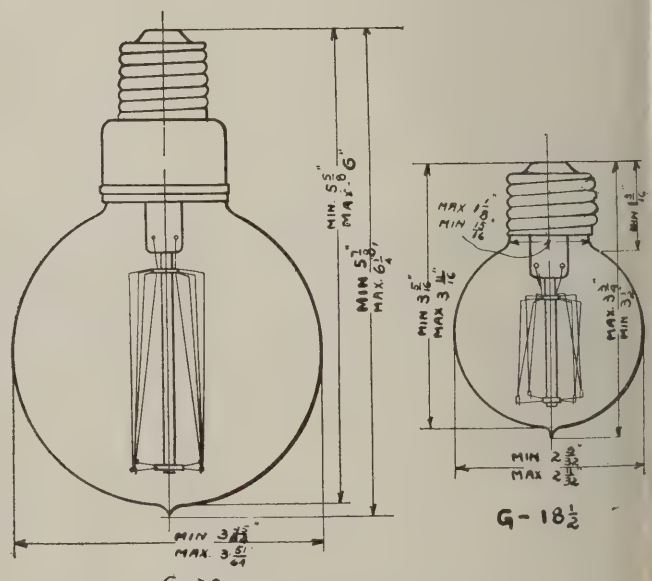


EXHIBIT "L"

Report of Committee on Standards

This part of the Committee Report was not received in time to be published in the advance copy of reports, but this should be considered as a continuation of the Report of the Committee on Standards given on page 122.—Ed.

At the last annual meeting held in Chicago on November 8, 1911, your committee submitted a report, containing twenty-seven recommendations for standard practice. These recommendations were submitted to letter ballot and unanimously adopted.

On March 21, 1911, these recommendations were given careful consideration by the Train Lighting Committee of M. C. B. Association, with the result that the recommendations of Train Lighting Committee of M. C. B. were changed. The suggestions of the 1912 Committee were submitted to letter ballot, with result that recommendations one to nine inclusive were adopted by the Master Car Builders' Association.

The subject of twenty-one of the twenty-seven recommendations adopted by our own Association, have been adopted by the M. C. B. Association, three have been incorporated in the M. C. B. Book of Rules and two have been recommended for future consideration.

For the information of our members, the adopted recommendations of our Association and the adopted recommendations of the Train Lighting Committee of the M. C. B., are included in this report. The various subjects were voted upon separately by letter ballot and adopted or otherwise disposed of, as stated below.

For convenience in making this report, the recommendations adopted by the M. C. B. Association are first noted, and the recommendations of the A. R. E. E. being noted second together with such comments as may be necessary for the better understanding of the subject.

Rec. No. 1 M. C. B.

That in electrically lighted cars the following voltages should be used:

60 volts (nominal) for straight storage, head-end and axle-dynamo systems.

30 volts (nominal) for straight storage or axle-dynamo systems.

Rec. No. 11 *A. R. E. E.*

That the following voltages should be used:

60 volts (nominal) for straight storage and head-end systems.

30 volts (nominal) for straight storage or axle-dynamo systems.

Rec. No. 2 M. C. B.

That each electrically lighted car be provided with a notice giving the following information, and that this notice shall be posted in the switchboard locker:

*System.
Type of Generator.
Type of Regulator.
Voltage of System.
Ampere Hours Capacity of Battery at 8-hour rate.
Number of Sets of Battery in Parallel.
Nominal Charging Rate—— Amps. ——max. amps.
Size of Train Wires—B. & S.
Number of Train Line Wires———(2 or 3).
Capacity of Generator———Amps.
Axle Pulley————in. diam.
Generator Pulley————in. diam.
Length of Belt———ft.———in.

*State whether axle dynamo, straight storage, and if used on head-end system.
Wiring diagram (show location and capacity of fuses).

Rec. No. 1 *A. R. E. E.*

That each electrically lighted car be provided with a notice giving the following information; that this notice shall be posted in the Electric Locker:

System.
Type of Generator.
Type of Regulator.
Type of Lamps.
Voltage of System.
Voltage of Lamps.
Number of Cells Storage Battery.
Normal Charging Rate (At Charging Receptacle) ——Amp.
Size of Train Wires, No. —— B. & S.
Number of Train Wires (2 or 3).
Capacity of Generator——Amp.
Setting of Axle Generator——Amp.
Setting of Auto. Switch——Volts.
Setting of Zero Charge Relay——Volts.
Setting of Lamp Regulator——Volts.
Capacity of Battery (At 8-Hr. Rate)——Amp. Hrs.
Ampere Load—All Lights (lights only)——Amp.
Axle Pulley——In. Diam.——In. Face——In. Bore ——
Generator Pulley——In. Diam.——In. Face.
Pulley Bushing——In. Diam. of Bore.
Length of Belt———Ft.———In.
Diagram of connection (showing location, type and ampere capacity of fuses).

Rec. No. 3 M. C. B.

That the rules of fire underwriters shall cover all car wiring.

Rec. No. 15 *A. R. E. E.*

That the rules of fire underwriters shall cover all wiring and installation of electrical equipment in cars.

Rec. No. 4 M. C. B.

That all wiring under car to the switchboard shall be run in conduit.

Rec. No. 16 *A. R. E. E.*

That all wiring under car to the switchboard shall be run in conduit.

Rec. No. 5 M. C. B.

Standard lamps for car-lighting service should be in accordance with dimensions as shown on Exhibit L.

Rec. No. 26 *A. R. E. E.*

That the style of lamp known as the G-18-½ with short Edison base mounted on globe in such manner that there is a ¼ in. neck between base and globe be used for train lighting. That when larger candle power is required the G-30 globe should be used for train lighting.

Rec. No. 6 M. C. B.

That where train-line connectors are used, a connector having dimensions as shown on Exhibit A shall be used and located as shown on Fig. 1, with connections to dynamo, battery and jumper as shown on Fig. 2.

If only two wires are used they shall be connected to the outside terminals and the female connector on each end of the car shall be stenciled, "Not for use on head-end system."

Rec. No. 2 A. R. E. E.

That all cars operated on head end systems, must be equipped with three train lines; that all cars furnished by a foreign road, for service in trains on head-end systems must be equipped with either permanent or temporary train lines, and the standard train line connector and receptacles.

That where train line wires are installed they must be fitted with standard train line receptacle and connector located as shown on figure one, with connections to battery, dynamo and jumper, as shown on figure two. If only two wires are used the center connection is to be omitted, and female receptacle marked—NOT FOR USE ON HEAD-END SYSTEMS.

That Standard connectors must be interchangeable with the No. 3 Gibbs connector and receptacle.

Rec. No. 7 M. C. B.

That each electrically lighted car, equipped with batteries shall be provided with two charging receptacles with swivel supports, as shown in detail on Exhibits B, C and D. installed one on each side of the car as shown on Exhibit E. the outside annular ring to be the positive.

Rec. No. 5 A. R. E. E.

That each electrically lighted car, equipped with storage battery boxes, must be provided with one or preferably two charging receptacles of sufficient capacity to carry 65 amperes of current without temperature rise exceeding 15° C., provided with a self-closing cover, and terminal connections to receive a standard charging plug.

The standard charging plug and receptacle must be interchangeable with the Anderson type "A."

The positive pole must be connected to the outside annular ring, negative pole to center post.

Rec. No. 8 M. C. B.

That each electrically lighted car shall be provided with a switchboard upon which shall be mounted switches, fused switches or terminals.

The switches, fuses or terminals to protect and completely disconnect the following parts:

(a) Train Line.
(b) Battery.
(c) Axle dynamo.
(d) Circuits for lamps, fans, etc.

The axle dynamo terminals to control the positive and negative armatures and the positive field of the dynamo. Each of the above switches, fuses or terminals to be plainly marked, designating the part controlled, the positive terminal to be on the right side facing the board.

Rec. No. 7 A. R. E. E.

That each electrically lighted car shall be provided with a switchboard; that on the switchboard there must be mounted switches, fused switches, fuses, or terminals, to completely disconnect the following parts:

(a) Train Line.
(b) Battery.
(c) Axle dynamo (where axle dynamo is used).
(d) Lamps.

The axle dynamo terminals to control the positive and negative armature, and positive field of dynamo.

The axle dynamo fuses to protect the positive armature, and positive field of dynamo.

Rec. No. 9 M. C. B.

Where a main lamp switch is used, or where fuses controlling all lamps are used, they shall be so stencilled in plain letters.

Rec. No. 8 A. R. E. E.

Where a main lamp switch is used, or where fuses controlling all lamps are used, they shall be so marked in plain letters.

Rec. No. 10 M. C. B.

The switchboard or regulator panels of electrically lighted cars shall be provided with fuses for the protection of the parts given below and with the type of terminal as specified:

(A) Train Line—Terminals for reception of flat fuses shall be provided 2½ inches between centers; stud or screw to be ¼ in. diam., with 20 threads per inch.

(B) Battery—Optional. Fuse terminals, if used, shall be same as for train line.

(C) Main Line Switch—Optional. Fuse terminals, if used, shall be same as for train line.

(D) Circuits—For lamps, fans, etc., fuse shall be of the Edison screw-shell type for both positive and negative.

(E) Axle Generator—Positive armature fuse terminal; terminals to have N. E. S. code standard 150 amps knife blade contact clips mounted with 4-inch clearance between clips.

(a) Axle Generator—Negative armature fuse terminal optional. If used, terminal shall be same as positive.

(b) Axle Generator—Positive field optional. If used, to have ferrule type clip mounted with 1-inch clear space between clips and to take N. E. C. code standard, 0 to 30 amperes.

NOTE:—Capacity of fuses, as designated above, to be such as to properly protect the parts in question.

Rec. No. 21 A. R. E. E.

The type of terminals for reception of fuses to be as follows:

(a The "Edison" screw shell for individual lamp and fan circuits.

(b) The Ferrule type of clip for axle generator field 1-in. clear space between clips.

(c) The knife blade type of clip terminal for reception of fuses 31 amperes or over, except as noted in Sec. f.

(d) The main generator fuse terminal on axle system to have 4-in. clear space between clips.

(e) The battery fuse terminals, close connected to battery under car, to have 4-in. clear space between clips.

(f) On the switchboard, the battery, mainlight and train wire circuits to be each provided with terminals for reception of fuses 2½ inches between centers, having wing nuts or machine screws, with washers for securing fuse or strap.

Rec. No. 11 M. C. B.

That each electrically lighted car equipped with battery box or boxes shall have provided a fuse block, mounted in a suitable metal box at the positive and negative terminals of each set of batteries, and that the fuse block shall be in accordance wtih the detail as shown on Exhibit F., and installed on the car substantially as shown on Exhibit E. Knife-blade fuses shall be provided with a capacity of between 101 and 200 amperes.

Rec. No. 6 A. R. E. E.

That each electrically lighted car be provided with two fuses close connected to each battery terminal; each fuse to be placed in a separate metal box; these boxes to be located on outside of battery box; the

fuses to be so connected that all current passing to or from battery must pass through both of them; the fuse block to have the N. E. C. 150 ampere knife-blade type of clip terminal with a clear space of 4 inches between terminals.

Rec. No. 12 M. C. B.

That where axle dynamos are used, negative, positive and dynamo field shall be fused as close as possible to the dynamo and prior to the said leads either entering the conduits or being secured to the bottom of the car. The above fuses to be used for emergency service only and to be at least one hundred above the capacity of the fuses on the switchboards protecting the same leads.

NOTE:—At the semi-annual meeting of the A. R. E. E., June 14, 1912 held at Atlantic City, the above recommendation was objected to. The sentiment of the meeting seemed to be rather opposed to extra generator fuses, and a motion was passed to that effect.

Rec. No. 13 M. C. B.

All wires or terminals must be marked for identification.

Rec. No. 24 *A. R. E. E.*

All wires at terminals must be marked for identification of polarity.

Rec. No. 14 M. C. B.

That batteries as a set shall be connected up with a positive pole to the right, facing the car as shown in Fig. 2.

Rec. No. 3 *A. R. E. E.*

That batteries as a set shall be connected up with positive pole to the right as shown on Fig. 2.

Rec. No. 15 M. C. B.

Where lead storage batteries are used they shall be preferably installed in double compartment tanks substantially as shown on Exhibits G, H and I.

Rec. No. 12 *A. R. E. E.*

That storage batteries shall be preferably be installed in double compartment tanks; that they should be installed in metal or rubber lined wood tanks, each tank provided with distance pieces, so that a clear space of at least ¾ in. is maintained between sides or bottom of the double compartment tank, and adjoining tank or sides and bottom of the battery box. Each individual tank, tray or crate must be marked so as to show ownership of battery.

Rec. No. 16 M. C. B.

That where double compartment tanks are used, the connections and arrangements of battery terminals are to be as shown on Fig. 3.

Rec. No. 4 *A. R. E. E.*

Same as above.

Rec. No. 17 M. C. B.

Battery boxes shall have provided in each door a vent, substantially as shown on Exhibit K.

Rec. No. 13 *A. R. E. E.*

Same as above.

Rec. No. 18 M. C. B.

That a straight pulley seat be provided for the axle pulley. That if a bushing or sleeve be used it should preferably be secured to the axle, independent of the pulley. Bushing to have an external diameter of 7½ inches and to be 8½ inches long, turned straight. That the pulley hub have a uniform internal diameter of 7½ inches, the length of the hub to be 6½ inches, the face of the pulley to be 9 inches or wider if flangeless and 8 inches if flanged. That the generator pulley be flanged, crowned and perforated and have a 7-inch face.

Rec. No. 17 *A. R. E. E.*

Same as above, except that the word "must" is used in place of the words "should preferably," in the third line of the M. C. B. Rec.

Rec. No. 19 M. C. B.

That when facng the end of the truck on which axle generator is mounted, the pulley or sprocket shall be on the right-hand side.

Rec. No. 14 *A. R. E. E.*

Same as above.

M. C. B. Book of Rules, Page 129.

On electrically lighted cars equipped with storage batteries or axle device, furnished to foreign roads, where no agreement is made, a charge of 75 cents per day shall be made for the use of electrical equipment.

Rec. No. 18 *A. R. E. E.*

On electrically lighted cars furnished to foreign roads, where no agreement is made, a charge of 75 cents per day shall be made for the use of electrical equipment.

M. C. B. Book of Rules, Page 138.

Electric current for charging batteries. At cost. Electric lighting material. At cost. Labor per hour 30 cents.

Rec. No. 19 *A. R. E. E.*

(a) On electrically lighted foreign cars where no agreement is made, a charge of 35 cents per hour shall be made for labor on electric repairs.

(b) That all material used in making repairs to the electric lighted cars of foreign roads, shall be charged at cost.

Rec. No. 20 *A. R. E. E.*

Current for recharging storage batteries, to be charged at cost.

The recommendations of the A. R. E. E. No. 9 giving dimensions of link type of fuses, recommendation No. 10 in regard to running wires in metal conduit, recommendation No. 23 location of storage battery boxes, recommendation No. 25 drop in voltage in car wiring and recommendation No. 27 in regard to generator suspension clearance, were not included in the recommendations of the M. C. B. Committee.

The M. C. B. Train Lighting Committee, however, recommended for future consideration the adoption of standard size of straight axles for different sizes for use with axle dynamos. They also suggested for further consideration, the design and adoption of standard arrangement of axle dynamo suspension.

At a meeting of the Executive Committee of the M. C. B. Assn. on August 13 and 14, the Train Lighting Committee was continued and were instructed to make a suitable recommendation in regard to standard design, construction and suspension of battery boxes or boots.

For your information, three of the seven members of the M. C. B. Train Lighting Committee, are also members of our own association. The A. R. E. E. Committee suggest that it may be advisable for our association to substitute or amend our own recommendations to conform to the recommendations of the M. C. B. Committee or make a protest, stating our objections to their recommendations.

Report of the Committee on Shop Practice

Your Committee on Shop Practice for this year feels that it can best serve the interests of the members as a whole by reporting on the broader phases of shop practice instead of taking any special feature and enlarging on that alone. We have, therefore, compiled information as to what the leading railway shop engineers consider good practice, as exemplified in the more recent installations and extensions.

So far as we have been able to determine, there is not a railway shop in the United States today in which electricity is not used in some form or other, especially for lighting. Where electricity is once adopted for any purpose, however insignificant, its extension and further application has always followed as fast as the management will permit. The shop men are practically unanimous in endorsing it for every possible practicable application.

In all new shops, and most of the old ones, electrical devices of every sort have been installed, these including lights, motors, cranes, welders, heaters, drills and telphers, and in many cases even the general design or layout of the shops and yards has been modified to take the greatest advantage of electrical operation. The latter is especially true of the crane. Originally the transfer table was the limiting factor, but, the large electric cranes can handle such heavy loads so readily and move them about so quickly that they are gradually taking the place of the transfer for all but the coaches.

Some application of electricity can be made in every department of railway shops, and it must be done if economical operation is to be realized. Ease of control, flexibility, wide application, efficiency, economy and ease of transformation are some of the reasons for its general adoption, but, the single characteristic, ease of control, is alone sufficient justification for its adoption whenever possible. Another very important reason is the possibility of having a central generating plant, thus reducing greatly the cost of power.

Most of the shops that are 20 years or more of age either no central generating plant or have one at one side or end of the group of shop buildings, thus causing inefficient distribution of power. In many cases the old shops have two or more boiler houses scattered about the yards, supplying steam to separate buildings for driving steam engines. Some of these engines drive generators, but most of them drive long lines of shafting direct. This condition is rapidly passing away now, due to the continued efforts of the electrical men, and will soon be a condition of the past only.

In modern railway shops all general utility buildings, such as the power plant, general storehouse, blacksmith shop, etc., should be as near the center of the group of buildings as possible, but the locomotive shop is the most important and is always the controlling factor. A study of recent shop layouts shows a growing tendency to concentrate the buildings along a craneway (the means of communication between departments) similar to the older method of keeping the buildings along the transfer table, and arranging the shops of each main group according to their respective functions. The Frisco and Big Four shops are good examples of this practice.

On the other hand, we find that physical conditions sometimes compel the adoption of a layout that is not economical, such as the necessity for locating the shop along the right-of-way of the railroad. Such an arrangement is not very convenient, but is operative and even efficient when electric power is adopted to the fullest extent. In fact, we find that the further a layout departs from the ideal the greater is the benefit to be gained through the adoption of electric power in place of any existing steam plant.

There is still a diversity of opinion as to whether direct or alternating current is to be used throughout the shops, but the majority favor the use of both systems. For hoisting devices and for variable speed motors the direct current still continues in favor, but recent developments in alternating current motors for

Typical Power Plant with Steam Turbine.

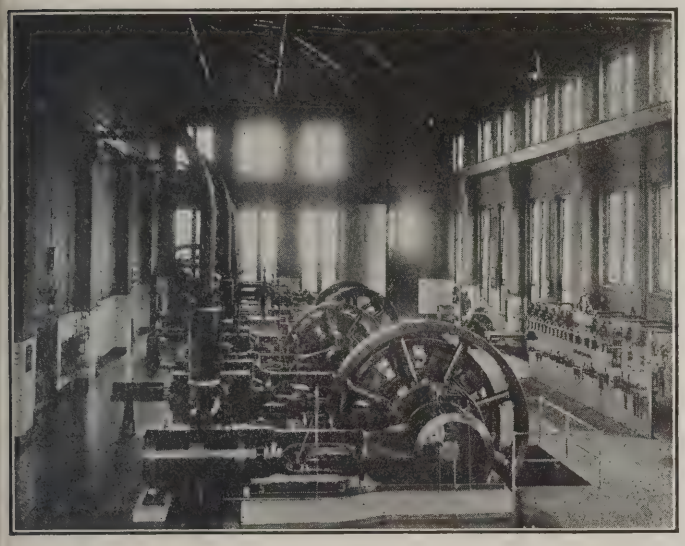
driving machine tools through speed change gears and by speed control have brought them to nearly the same degree of flexibility as direct current motors. Practically the only factors to be considered are the power factor of the system as a whole, the slight differences in the cost of maintenance and the small drop of voltage in distribution. Such differences as there are show in favor of the alternating current system at present.

Power Plant.

The best location for the power house is undoubtedly as near the center of the load of the plant as possible. This means ultimate load as well as present load, in so far as they can be determined. This is especially true of direct current plants on account of transmission losses, due to the general use of lower voltages than with alternating currents. The easy and adequate supply of coal and the removal of ashes must be considered, and these frequently influence both the design and location of the power house.

When laying out the power plant, the building should be made to suit the equipment and not the reverse, as has frequently been the case. Plenty of room should be provided for convenient operation and for extensions, and a clear space in front of the switchboard should always be provided. The best and pre-

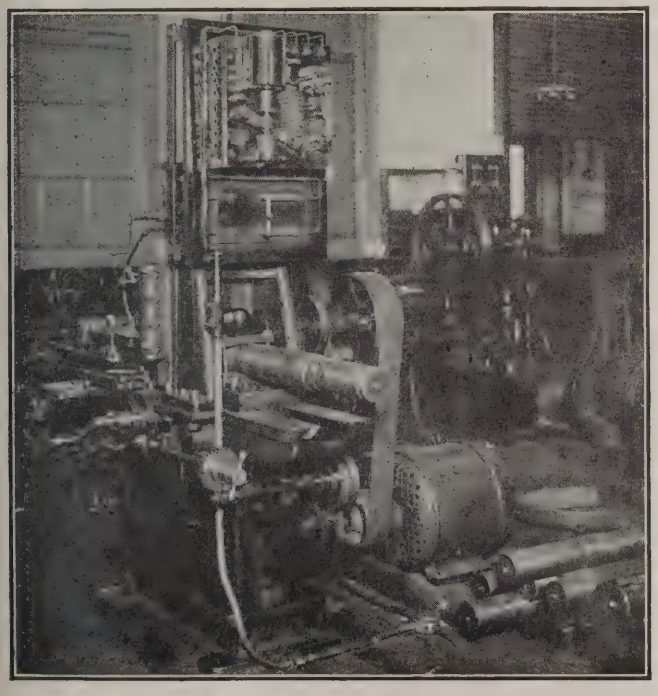
ferred location for the switchboard is about the center of one wall of the engine room and immediately in front of the generators. The danger of trouble due to breaking of fly-wheels is remote, while the reduction in the length of cables and wires between the



Typical Power Plant with Reciprocating Engines.

machines and switches is considerable.

Steam turbines are being used to a very large extent in railway power plants, due to their small size and greater economy than reciprocating engines, but there is still much to be said in favor of the latter. They are favored by many engineers for driving direct current generators, with the turbine as the favorite for alternating current machines. One point which has always been mentioned in favor of the reciprocating engine is the use of its exhaust steam for heating the shops, but this applies only to non-condensing engines, usually. Recent developments in



Typical Motor Driven Milling Machine.

steam turbines have brought about a type designed especially with a view to using it in connection with steam heating systems. The large amount of glass used in railroad shops, with the consequent great radiation of heat, makes the heating problem an important one, but beyond the province of this report.

The switchboard is a much more important part of the power plant equipment than many engineers seem to realize, if we are to judge by some of them now in service. It should not merely contain panels enough for all of the generators and feeders, but each panel should have a complete equipment of meters, switches, etc., in order to allow of the fullest knowledge and control of conditions in each circuit. You cannot operate in the dark any better than you can see there, and a few more dollars spent on the switchboard will usually result in great benefits in operating the shops.

As previously stated, your committee feels that it really makes very little difference whether direct current or alternating is used, so long as the local conditions have been carefully studied and the most suitable equipment chosen. If the power is to be transmitted over any very great distance, which seldom happens in railway shops, the voltage should be as high as possible for safety, in order to reduce the amount of copper required for the lines and to keep the terminal voltage up to as nearly normal as possible. Either a. c. or d. c. distribution can be made safely at 440 volts and this is high enough for any railway shop at present constructed, and if the power plant is properly located it will do for any plant that will probably ever be constructed.

Distribution of power to the various shops may be done through overhead or underground lines, the present tendency being to construct tunnels through the yards and to have all steam, water and air pipes and electric cables in them. This makes frequent inspection easy and results in fewer cases of trouble and delay due to breakdowns. We feel, however, that the electric distribution system should be kept away from the heat of the steam pipes and believe that the practice of putting the cables in ducts placed alongside the tunnel, instead of having them in it, is better practice. This plan is followed in the Big Four shops at Beech Grove, Indianapolis.

Overhead lines are carried along the buildings in many of the older plants and on wooden poles in others, with steel poles and towers in several of the later plants. At the West Albany shops of the N. Y. C. & H. R. R. R. all wiring for the distribution system is on steel towers, separate cables and wires being run from the switchboard to each department in the shop. The general practice is to run a heavy feeder to each building or group of buildings and then to distribute from a common center to each department.

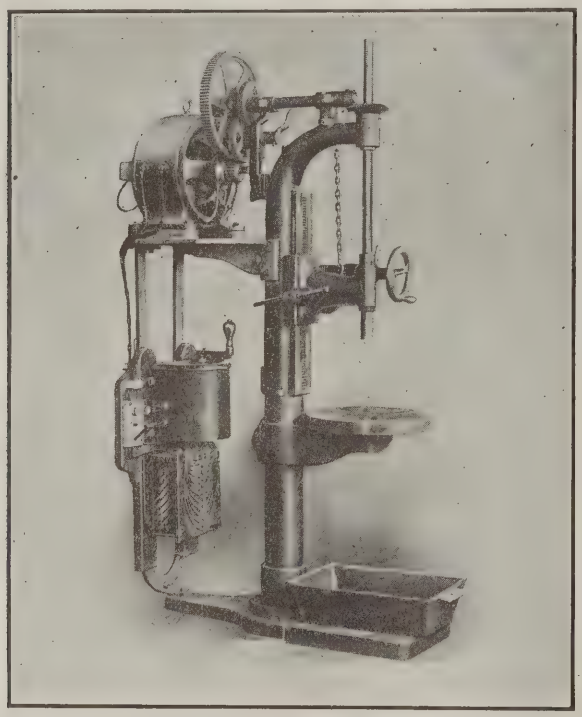
Where alternating current is used it is customary to locate transformers at the various distribution centers for stepping down the voltage to that required for the lights or motors. Usually these are located on poles outside the buildings, sometimes inside, but when the distribution system is underground the transformers must be inside the buildings or in manholes. At the Pullman shops manholes are placed at each of the principal distribution centers, outside the buildings, with the step down transformers therein for reducing the voltage from 2,300 volts to 110, 220 or 440 volts as required.

Shop Equipment.

Turning now to the matter of adopting electric drive for railway shops, we find that most of the adverse criticism which has been made regarding electric drives has been the natural result of the errors made, by made managers and superintendents,

through making radical changes in equipment without first making a careful study of conditions. Each shop presents conditions of its own, but all of the details can be obtained by taking the time to go into the matter. One of the most important things is a good set of accurate records of time, operations, materials, machines men and methods. Another is as to whether group drive or individual drive is going to be best for any one department or the entire shop.

The sizes of motors recommended by the machine tool builders has been found, in many cases, to be much larger than actually necessary for satisfactory operation. Tests conducted under various operating conditions have been made by several of the roads in their shops and much valuable data has been compiled, and considerable money saved. The use of graphic meters in this connection is proving very helpful and several reliable makes are now on the market. Re-

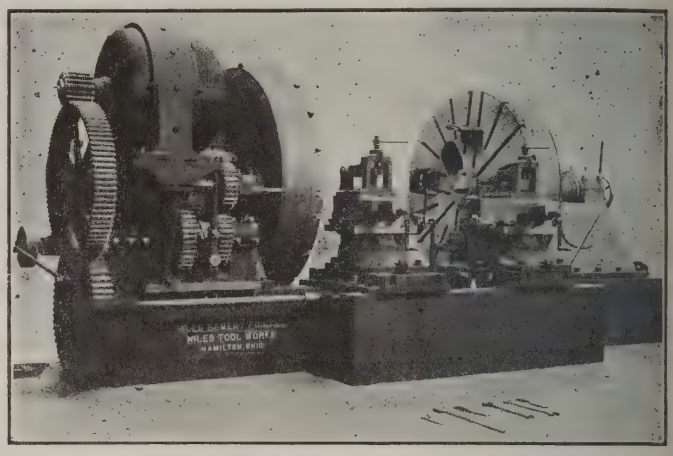


Typical Individual Drive for Drill Presses.

liable data as to the power required to drive the different classes of machines is hard to get, so the best thing to do is to test your own machines under your own operating conditions and find out.

We find that there is practically no argument as to the use of anything but electric motors where they are at all applicable, and that means practically any place where power is used to produce motion. Among the benefits gained through their use are decreased transmission shaft losses, increased production through easy speed control, accurate knowledge of power required for any given purpose, ease of power control and distribution, flexibility of machine arrangement, reduced vibration of buildings and machines and the elimination of most belt troubles.

Series-wound motors have been found best adapted for use where the operator has the motor always under his control, as for hoists, cranes, elevators, locomotives and other classes of intermittent service requiring high starting torque. Shunt-wound motors, because of their speed characteristics and ease of control, are particularly well adapted to driving machine tools. Experience shows them to be best fitted to drive tools which do their work with a rotary motion of either the work or the cutting tool. This includes drills, lathes, boring mills, milling machines, etc., and for this service we find a preference shown for shunt-wound, variable speed motors. Compound-wound motors have proven most acceptable for driving planers, shapers, slotters, rolling mills, punch presses and other machines with a reciprocating motion of either the tool



Variable Speed Motor Driving Wheel Lathe.

or the work. Fly-wheels have been found a great help to compound motors through smoothing out the load curve.

Alternating current motors are built in several forms and some of them possess certain advantages over direct current motors for special classes of service. Synchronous motors operate at constant speed regardless of load, up to the stalling point, so long as the speed of the generator supplying them remains constant, and are useful for driving generators and other apparatus requiring constant speed regardless of load. There should always be one in induction motor driven shops in order to bring up the power factor of the system.

Induction motors operate at very near synchronism at no-load and from 3% to 15% below synchronism under full load, depending upon the size and characteristics. Induction motors arranged for the insertion of resistance in their secondary or armature circuits will operate at nearly full load torque with the speed reduced one-half without overheating, so are being used in many places where direct current motors were formerly used exclusively.

Induction motors with squirrel cage or short circuited rotors have proven satisfactory for use where speed variation is unnecessary during a given operation, such as for pumps, fans, drills, grinders, wood working tools and other places where motors with the characteristics of shunt-wound direct current motors are required. Speed variation can be obtained only through varying the voltage or with speed changing gears, neither or which is very desirable, although machine tool makers supply speed change gears on nearly all machines now for this especial purpose.

Squirrel cage motors are good for use in oil houses, wood working shops and other places where inflammable materials are found as there are no moving contacts and no sparking. Induction motors with variable secondary resistance may be run at speeds of anywhere between half speed and full speed, at full load, and are suited to most any class of service that either shunt or compound direct current motors are. Reversing induction motors are now available which will reverse almost instantly and are especially adapted to driving planers.

The present tendency in locomotive shop equipment is to increase the number of machine tools per pit. The average is between 6 and 8 per pit with many shops having from 5 to 6, but the tendency is towards from 8 to 10 per pit in several of the newer shops. There is no fixed rule, apparently, as to how many tools of each kind will be required per pit, but an average of a large number of shops shows the following proportions:

Turning Tools	50%
Cutting Tools	25%
Drilling Tools	11%
Grinding Tools	7%
Miscellaneous	7%

Electric Crane with Lifting Magnet.

Several tables have been published purporting to show the proper number of tools of each type and size for different numbers of pits, but do not find that they are followed because of the differences in local conditions. For boiler shops, the average is about one tool for each pit in the erecting shop, there being seldom more than one tool of each kind aside from drills and shears. Aside from cranes and a few motors for driving punches, fans, blowers, shears, etc., there is not much electrical equipment in blacksmith shops, although overhead motor driven cranes are gradually superseding hand and air operated cranes.

Chilled wheel shops and other foundries are more commonly found in railway shops than formerly, these using electric cranes, motor cars, motor driven tumblers, grinders, chippers, etc. Cranes of 10 tons capacity are most commonly used in railway foundries, with hoists of from 1 to 5 tons in the side bays. Electric welding apparatus is also being used to a small extent for repairing castings, and for spot-welding small pieces to larger ones.

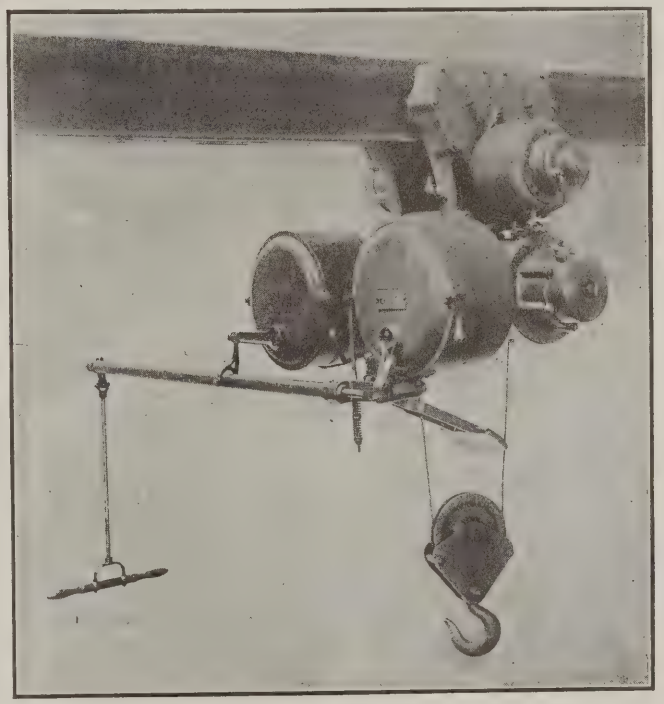
Nearly all wood working machines in electrically operated shops are fitted with individual motors because of the comparatively large amount of power required. Induction motors with squirrel cage windings are used for this purpose on account of the freedom from sparking and the constant speeds. Wood shop equipments include planers, saws, mortisers, tenoners, moulding machines, boring machines, gainers, matchers, etc., and motor driven blowers for carrying off the shavings.

The use of the automatic controlling devices is increasing and we strongly recommend their adoption wherever possible. Suitable devices for both variable and constant speed motors are now available, most of them being arranged for push button control. The use of push buttons is a move in the right direction as it reduces the chances of injury to both workmen and tools, and makes it so easy to start and stop the machines that the men will stop them during idle periods instead of allowing them to run and waste power. The automatic starters also have certain protective features which are valuable, most of them opening the circuit on overload.

Mechanical speed change gears separate from the backgearing are coming into use to some extent in connection with constant speed alternating current motors, these being made in a variety of forms for many purposes. Some of these use short belts as the transmitting element and others use gears.

Another very useful practice is being followed in regard to compressed air supply. This is the placing of small motor driven air compressors in all shops requiring air outside of regular working hours. In this way a small amount of compressed air may be provided without operating the large air compressors in the main power houses.

Storage batteries are not used about railway shops much as their possibilities seem to warrant. They may be used to good advantage for operating the red lights at fire hose stations, for general tungsten light-



Typical Electric Trolley for Shop Telpher Systems.

ing in many other ways as an emergency supply in case of trouble at the power house or in the transmission lines. Many other applications could be made and we feel that this is worthy of further consideration.

The use of electrically operated safety devices of a variety of kinds could also be extended to good advantage, and a new system for this purpose will soon be placed on the market. This is designed to stop the machinery instantly in case of accident and may be operated from any part of the shop Automatic fire

alarm systems are also being neglected and the risk greatly increased as a result, with no good excuse. This is also worth consideration and improvement.

Aside from the shops mentioned the applications of electric power around railway shops is limited to special applications. Among these may be mentioned turntables, yard cranes, pump motors, hoists, portable drills, polishers, paint sprayers, etc. Another application which is becoming very common now is the increasing use of electro-magnets for picking up iron and steel. These are made in both large and small sizes and are used for handling plates, rails, bars, pig iron, kegs of small parts and for lifting the "skull crackers" in the scrap yards. The round houses, sand sheds, water towers, private hospitals, coaling stations, store houses and other small departments all have their special applications of electric power.

Lighting.

A very careful and complete investigation of the matter shows that the preferred system of lighting is a combination of all systems. The best system of illumination for the large shops is a combination of flaming arc lamps for general illumination with tungsten clusters for group lighting and drop lights for machines when required. The individual lighting of machine tools is very important and is receiving more attention than formerly, because, good lighting consists in throwing the light on the work and not in the eyes of the worker.

The flaming arc lamp has proved itself best suited for large areas, such as locomotive shops, foundries, yards and blacksmith shops, because of its high power and great penetrative ability. Mercury vapor lamps are used to some extent in medium sized shops and power plants, and tungsten lamps of all capacities are used to an increasing extent in machine shops, mills, power plants and other places where there is no vapor or smoke to penetrate. They are especially good in blacksmith shops and foundries on account of their ability to penetrate smoke.

For the offices and drafting rooms the indirect and semi-indirect systems are rapidly coming forward on account of the freedom from glare and the pleasing appearance. Carbon filament lamps are still preferred for drop lights on account of their ability to stand rough handling, but the new drawn-wire filament for tungsten lamps is much better than the first ones brought out and are being used to some extent. Guards should be placed on all drop lights to prevent breakage and for protection from fire.

This committee recommends that all wiring be run in conduits, wherever possible, and that cut-outs be installed for each shop, department and machine tool. If the main cut-out for the shop cannot be placed inside the building it should be placed where convenient for instant access in case of necessity. Where small portable tools are used there should be receptacles at frequent intervals for the plugs on the tools, these receptacles being on the walls or columns of the buildings near the point of application of the power. This applies also to portable lights. For stationary tools the conduits should run under the floor to the tool instead of having the wires drop from overhead or out from the wall.

It seems almost unbelievable that so many shops have adopted electric power to such a small extent as some of them have, but many of them have not availed themselves of this convenient form of energy for other than lighting. This committee, therefore, feels that its best and most important recommendation for this year's report is that all railroads should equip their shops with electrically operated apparatus to the fullest possible extent throughout, and at the earliest possible moment.

Respectfully submitted,

C. J. Causland, Chairman, Chief Elec., Pennsylvania R. R. (West.)
Geo. W. Cravens, Pres. Cravens Elec. Co.
J. C. McElree, Chief Elec. Mechanical Department, Illinois Central R. R.
Willard Doud, Shop Eng., Illinois Central R. R.
A. J. Collett, Elec. Eng., Union Pacific R. R.
Geo. E. Murray, Shop Elec., Chicago & Northwestern R. R.
F. H. Herzsch, Ind. and Power Department, Westinghouse E. & Mfg. Co.

Committee on Shop Practice.

Logan Shops of the Hocking Valley Railway.

The repair shops of the Hocking Valley Railway, at Logan, Ohio, offer a very interesting example of a thoroughly up-to-date railway shop of moderate size. Alternating current is used throughout, three phase, 60 cycle, Allis-Chalmers equipment being installed. There are 41 motors in these shops, most of them direct connected to the machines they drive, 87 Adams-Bagnall arc lamps and 333 incandescent lamps. The lights are distributed throughout the shops in such a way as to insure the very best illumination for the different departments.

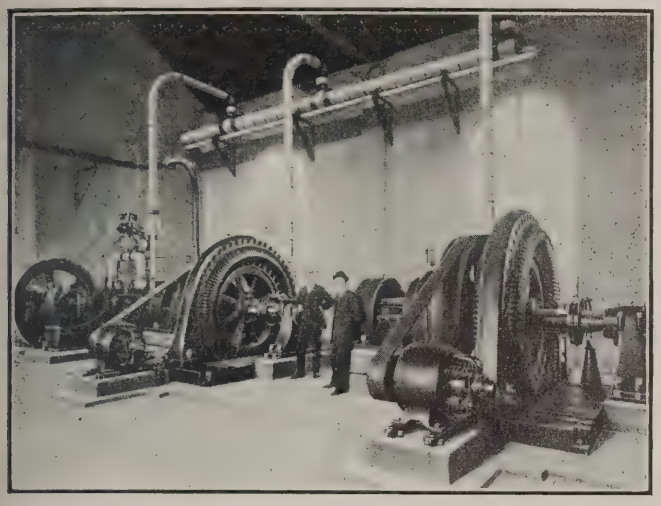
Power Plant.

The power house is centrally located with reference to the center of load, and contains 2 Allis-Chalmers 200 k. w. 240 volt, 60 cycle, 3-phase alternating current generators direct connected to Buckeye engines. These generators are "star" wound and the exciters are belt driven, the generators giving current at 240 volts for the motors and at 140 volts for lights.

A tie-line connects this plant with that of the Logan Light and Power Company's day service through four 10 k. w. 2300 volt step-up transformers. These transformers are also used as step-down transformers for night service at the shops, being specially wound to give both 140 and 240 volts. They are controlled by a double throw, seven pole knife switch on the rear of the switchboard.

The mechanical equipment of the power plant includes a compound, steam driven air compressor; three 200

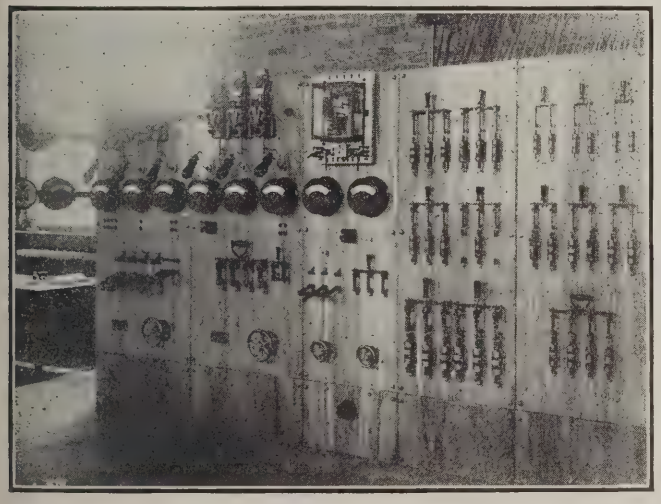
h. p. McNaull water tube boilers equipped with Jones under-feed stokers; two Worthington high pressure, duplex pumps; two boiler feed pumps; a Webster water heater and an American blower engine for forced draft.



Interior of Power Plant.

Distribution System.

All wiring for power consists of No. 0000 weather-proof cables and all lighting circuits are of solid wires of proper capacities. At present, all distribution lines are overhead on pole lines to the different departments, but they will soon be placed in a tunnel which has been installed for the steam and compressed air distribution system.



Switchboard in Power Plant.

This shop follows the same plan as the N. Y. C. & H. R. R. in its West Albany shops of having separate circuits from the power house to each department. There are three 240 volt motor circuits to the planing mill; one 240 volt motor circuit to the blacksmith shop; two 200 volt motor circuits to the erecting shop; one 240 volt motor circuit for the cranes; one 240 volt motor circuit each to the round house and wheel and axle shop; and separate 140 volt lighting circuits to each of the shops mentioned. A separate switch on the switchboard controls each circuit and a distribution center is located in each department to control its local circuits.

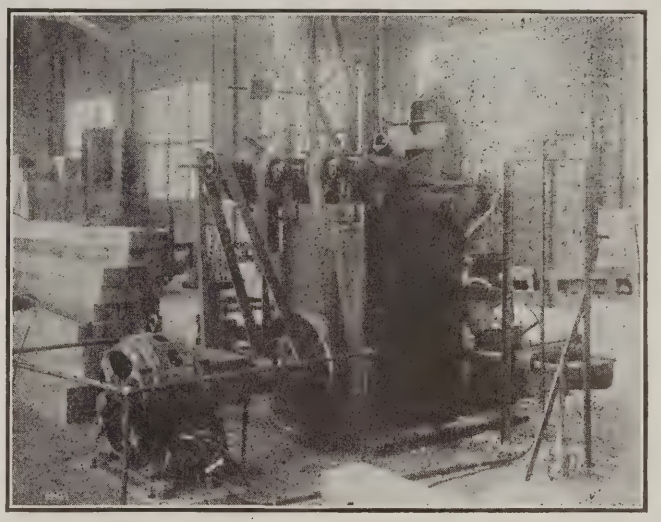
Motors.

The 41 motors in these shops are distributed as follows;—

Planing Mill—15 hp. on gainer; 15 hp. on tenoner; 5 hp. on swinging cut-off saw; 50 hp. on large timber sizer; 15 hp. on cut-off saw; 15 hp. on mortiser; 15 hp. on combination tenoner and mortiser; 15 hp. on combined jointer, sticker and small rip saw; 15 hp. on table rip saw; 50 hp. on planer and matcher; 20 hp. on three spindle boring machine, band saw, emery wheel and bit grinder; 10 hp. on gainer and borer; 30 hp. and 50 hp on dust fans and 15 hp. on steam heating system fans.

Erecting Shop—40 hp. and 50 hp. on steam heating system fans; two 10-ton and one 15-ton cranes inside and one 5-ton crane on outside runway. The cranes are each equipped with three General Electric motors.

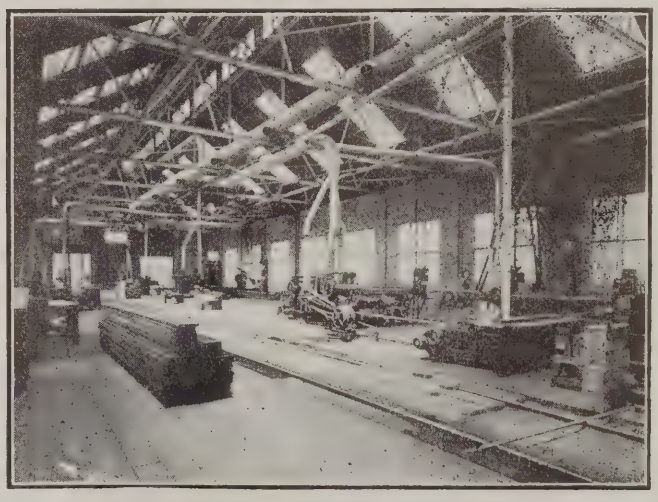
Blacksmith Shop—15 hp. on a group consisting of a Bradley hammer, emery wheel, grind stone and drill



A Mortiser Driven by a 15 h. p. Ind. Motor

press; 15 hp. on gang drill; 30 hp. on bull-dozer and combination punch and shears; 30 hp. on group consisting of one 1½" and one 2½" bolt headers, eye bender, guillotine shears and four bolt cutters; 40 hp. on blast fan for forges, and a 15 hp. on a large rip saw which is used for cutting up old lumber for use where such material is practicable.

Wheel and Axle Shop—30 hp. on group consisting of wheel boring machines, axle lathe and two pipe



Saw Shop Equipped for Motor Drive.

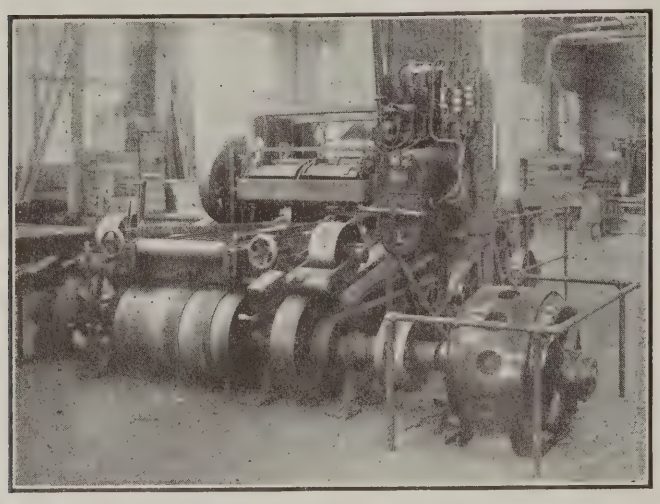
threading machines; 7½ hp. on hydraulic wheel press, and 5 hp. on group consisting of drill press, emery wheel and angle cock grinder.

Round House—15 hp. on Weinman pump for round house and engine use, and 15 hp. on a group consist-

ing of three lathes, a drill press, emery wheel, shaper, planer and bolt cutter.

Tunnel.

The tunnel above mentioned, which was put in this year, contains the steam heating pipes for the entire shop. A 12" exhaust steam header with 1½ lbs. pressure and 4" vacuum line for return is laid through the main tunnel, branches of the required sizes being taken off for the various shops. There is also a 4" high pressure steam line for the steam hammers in the blacksmith shop, and is the intention to eventually have all compressed air pipes in the tunnel, also.



Motor Driven Planner and Matcher.

The main tunnel leads from the power house through the yards and is 6 ft. high by 6 ft. wide and is made of reinforced concrete. Hanger bolts are placed in the top and at one side for supporting the electrical distribution lines when they are placed there later.

Blacksmith Shop.

In conclusion, the writer desires to express his thanks to Mr. M. A. Kinney, Superintendent of Motive Power of the Hocking Valley Railway Co., for his kindness in sending the electrical data, and the Allis-Chalmers Company for supplying the photographs used herein.

Motor Talk No. 2

SHUNT WOUND MOTORS

In the first article of this series we discussed the most important characteristics of the three principal type of direct current electric motors, shunt, series and compound. This time we will deal with the shunt motor as it is the most used and most useful motor in a machine shop.

As its name indicates, a shunt motor is one in which the field windings are connected directly across the line instead of in series with the armature; i. e., the field current is "side tracked" around the armature instead of following the main line through it. Hence, the strength of the field will be constant because it is always subject to the same voltage and its resistance is constant, unless purposely varied. And this is true regardless of load, up to the capacity of the motor.

The field coils of shunt motors are made of comparatively fine wire, offering considerable resistance to the flow of current, so there is very little chance for trouble due to connecting them directly across the circuit. The armature, on the other hand, is usually wound with very large wire or bars of copper and its resistance is comparatively low, generally a small fraction of an ohm for moderate sized motors. That is why the rush of current at starting may be 10 to 20 times the normal full load running current.

The armature resistance is made low in order to get uniformity of speed, the variation from no load to full load being less than five per cent in good motors. The only reason there is any variation is because of the slight de-magnetizing effect of the armature on the field. When a shunt motor is running free the only current taken from the line is that required to overcome internal losses, such as friction, etc., and the speed of the armature will be such that the counter E. M. F. of the motor will allow only enough current to flow to overcome the losses and operate. The counter E. M. F. should be nearly equal to the line E. M. F. in a good motor.

When a shunt motor is loaded it must take enough current to produce the torque or pull necessary to carry the load or it cannot run. In order that this current may flow, the counter E. M. F. must be reduced, hence, the speed must drop a little because the field strength is practically constant. A well designed motor with low armature resistance will have to drop but little in speed at full load. There is very little tendency for shunt motors to run away upon removal of the load because of their automatic self adjustment to conditions.

Figure 6 shows the connections of a starting rheostat with a shunt motor. The main current passes through the motor armature and the rheostat arm and resistance, while the shunt or field current passes through the field coils and rheostat release magnet and resistance. The function of the release magnet is to hold the arm of the rheostat in the running position until there is a failure of voltage on the line, allowing the arm to fly back to the starting position when the voltage fails. This may be due to line trouble or to opening the main switch controlling the motor circuit.

When the rheostat arm is in the starting position the armature current has to pass through all of the resistance and the flow of current is limited, but as the arm is moved over to the running position against the magnet the resistance is gradually cut out and the flow of current increases as far as the counter E. M. F. will allow. At

the same time, the current flowing through the field coils is greatest when the arm of the rheostat is in the starting position, but is reduced by the resistance cut in circuit as the arm is moved over to the running position.

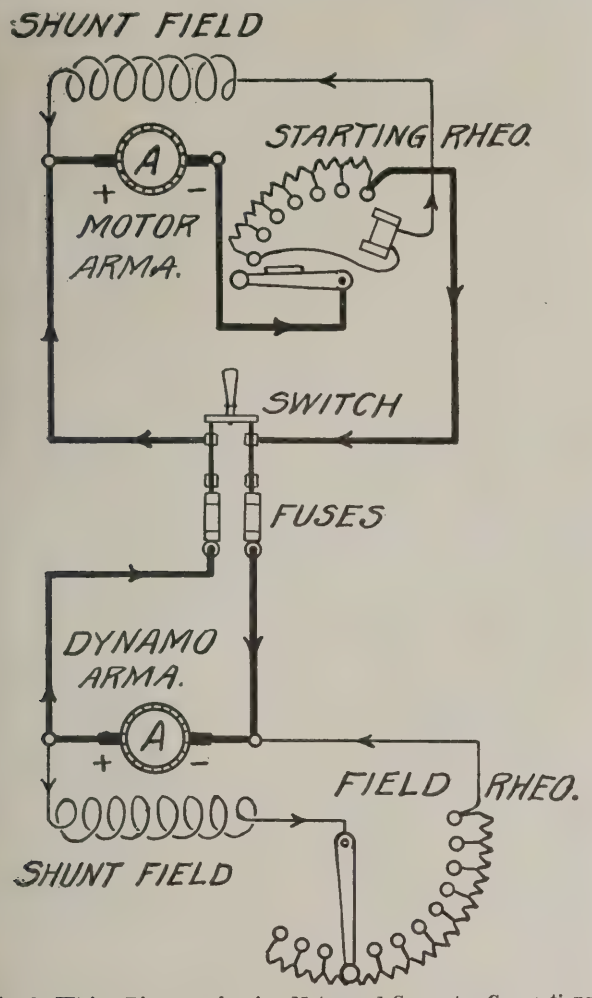


Fig. 6. Wiring Diagram showing Motor and Generator Connections.

This reduces the strength of the fields and causes the motor to run faster in order to generate the required amount of counter E. M. F.

For a large number of machine tools it is desirable to vary the speed of the motor in order to turn out work with the greatest efficiency. This may be done in several

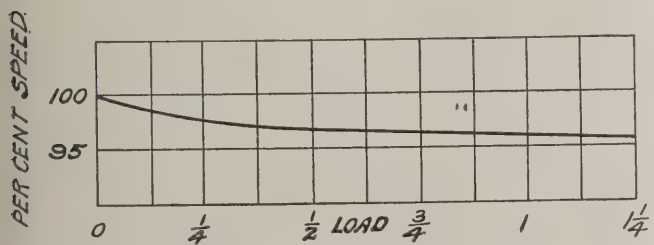


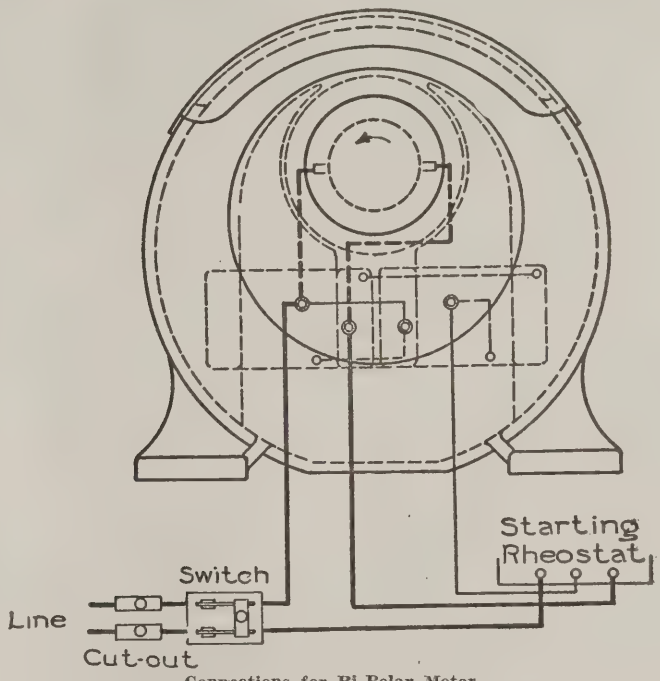
Fig. 7. Speed Load Curve for a Shunt Motor.

ways, the simplest being to insert resistance in series with the armature. But this is wasteful, because the energy not used in the motor is dissipated in the form of heat by the resistance box. It is also bad because the rheostat will have to be quite large and expensive and because the speed of the motor will vary a good deal unless the resistance is constantly varied to suit.

A much better method, and the one generally used, is to vary the field strength by means of a resistance in series with the field windings. Since the field current is small, being from 2 to 5 per cent of the armature current, a rheostat for field control will be comparatively small. By cutting out resistance the flow of current will increase, the field will be strengthened, the number of "lines of force" increased and the armature speed reduced. Cutting in resistance has the opposite effect, so the action is easily understood.

The only disadvantage in this method of control lies in the increased sparking at the brushes on the commutator, on account of the weakened field at high speeds, and a smaller torque will result at the higher speeds. It must be remembered that shunt wound motors are designed to give constant horsepower at all speeds, so greater torque must be developed at slow speeds than at high speeds to give the same output. In order to give the required output we may have to use a 15 h. p. frame to give 10 h. p. at half speed and a 20 h. p. frame to get 10 h. p. at one third speed. That is why variable speed shunt motors are so large in proportion to their capacities.

Another method of varying the speed of shunt motors is by varying the voltage applied. With the field of the motor kept at constant strength and a varying voltage applied to the armature the speed will vary in almost



Connections for Bi-Polar Motor.

direct proportion to voltage variation. With the ordinary three-wire system the speed can be reduced one half by connecting the armature across the middle and an outside wire instead of across the two outside wires. By using four wires and generators of three voltages we can get six variations of speed, and so forth. But this method requires quite complicated switching devices and is not used very extensively, in spite of its efficiency. From these descriptions you can readily see which method will best suit your operating conditions.

The Question Box.

Editor Shop Motor Section.

Will you please answer a question for me in your Shop Section? Several of use fellows here have had an argument as to how much horse power we could get out of a generator we have if we ran it as a motor, and we wish you would tell us.

This is a shunt connected dynamo operating on a 100 volt circuit, and takes 100 amperes when running at 1200 RPM. The resistance of the armature is about

.035 ohm and of the field coils about 50 ohms. The watts lost due to friction, etc., are about 325 watts.

It is supposed to be a 10 kilowatt generator and some of the boys say it should give about 15 h. p., but I think

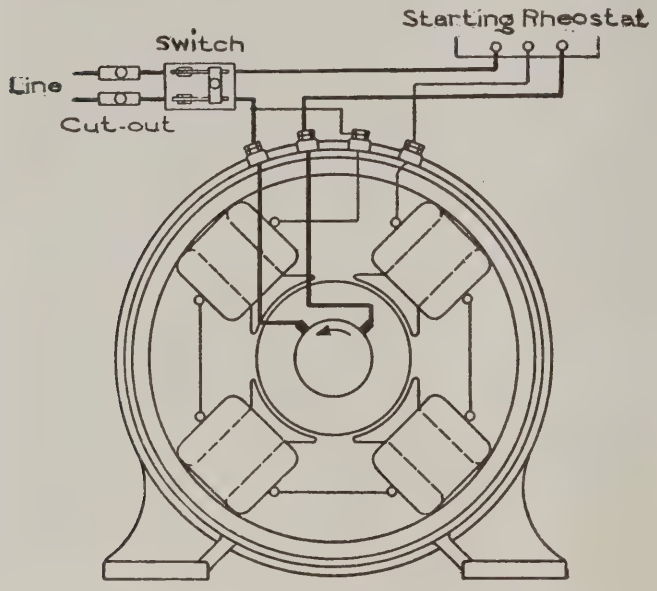
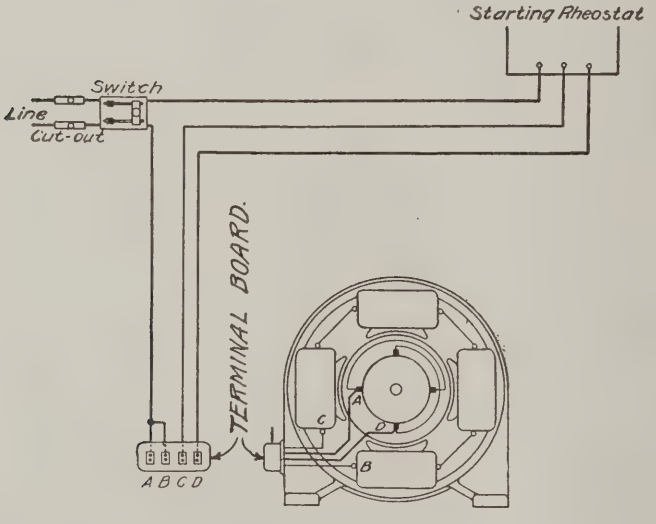


Fig. 9. Connections for Four-Polar Motor.

it wont give much more than 10 h. p. What do you think?

F. B. K.

ANSWER.—Since the resistance of the field coils is 50 ohms there will be 2 amperes flowing through them,



A and D are Armature Terminals
B and C are Field Terminals
Motor Connected for Counter Clockwise Rotation
For Clockwise rotation interchange external connections to B and C at the Terminal Block

Fig. 10. Four-Pole Motor with Terminal Board.

and since there were 100 amperes flowing when running as a generator we will assume the same current in the armature as a motor. This is a fair assumption because the Counter E. M. F. would reduce the flow greatly after the motor came up to speed. At starting, the current would be about 3000 amperes for a small fraction of a second (100 volts divided by .035 ohm) but the C. E. M. F. will soon cut it down.

When running as a dynamo the loss in the armature was 100 x .035—3.5 volts, so the total E. M. F. actually generated must have been 103.5 volts at 1200 r. p. m. There will also be 3.5 volts lost as a motor, leaving 96.5 volts to overcome the C. E. M. F. The speed will be 1118 RPM (96.5 divided by 103.5 and multiplied by 1200) and this is what you will have to figure on when determining your pulley sizes.

The strength of the magnetic field will be the same as before, of course, so the total mechanical rate of doing work will be equal to 100 amperes (armature current) x 96.5 volts, or 9650 watts.

The friction, etc. loss will be 325 watts, as before, so you will have 9325 watts left for external work. Since it takes 746 watts to equal one electrical horse power, your generator will develop 9325 divided by 746 or 12.5 h. p. at the pulley. By following this method you can determine what any generator will do when run as a motor. G. W. C.

Metor Talks to be Continued Next Month.

NEW BENJAMIN CAR FIXTURE.

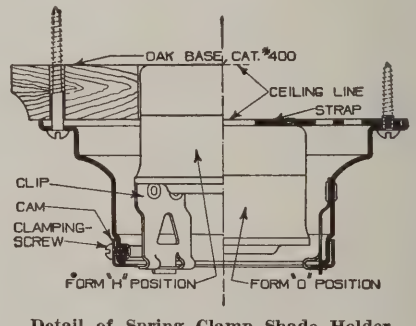
The Benjamin Electric & Manufacturing Company of Chicago have just placed on the market a new single unit car fixture and lamp grip as shown in the accompanying illustrations. The fixtures are intended for single unit car lighting and will accommodate standard glassware with 2¼-inch neck. The shade is held securely in position by three spring clips which are forced into engagement with the neck of the reflector by means of a cam ring. The latter

Spring Clamp Shade Holder.

Lamp Grip.

in turn is bolted to the casing so it cannot jar loose.

The entire fixture is made of spun brass, hence it is light, but it is made of sufficiently heavy stock to make a substantially built solid fixture which will withstand the severe jarring and jerking experienced in railway car lighting service.



Detail of Spring Clamp Shade Holder.

This company has also recently placed on the market the new Benjamin Lamp grip which is designed to prevent the loosening and falling of lamps. A simple spring engages the lamp base with sufficient force to hold it in position; yet this does not bind. When it is desired to remove the lamp, a slightly greater twist is all that is necessary. This grip device prevents lamps from working loose and eliminates the breakage and danger from falling lamps, and at the same time makes it unnecessary to readjust or tighten lamps periodically.

The First Storage Battery Train in Railroad Service

On September 25th a train, consisting of three storage battery cars, left the Pennsylvania station, New York, on its first trial trip. The train carried 140 railroad officials, banking officers, and representatives of the press. It made a round trip from Pennsylvania station to Long Beach, Long Island, a distance of 24.6 miles.

The train is operated by a unique system of magnetic multiple control and can be operated from either end of any car by a master controller placed on each platform. This master control is fitted with a control and reversing lever which are mechanically interlocked. Four speeds can be obtained from the master control. In the first position the motors are started with two pairs in series with the starting resistance. In the second position all the starting resistance is cut out automatically, leaving the motors running in full series. In the third position the two pair of motors are connected in multiple in series with the starting resistance and the resistance is cut out automatically, leaving all motors connected in multiple across the power battery. In the fourth position the series field of each motor is paralleled with resistance, which further increases the speed. This sequence of operation takes place simultaneously on each car and is accomplished through the train line consisting of two wires which run through all the cars and is connected to all master controllers, relay panels and polarized relays.

The First Storage Battery Train Ready for Trial Trip.

The interior finish is of mahogany and polished bronze, the exterior being of cedar, while the underframing is entirely of steel construction.

These cars are equipped with M. C. B. couplers, draft rigging and buffer plates; platforms are full vestibuled with end doors, allowing intercommunication between the cars. The brake equipment consists of a powerful hand brake as well as the Westinghouse A. M. M. automatic air system, controlled on platform of any car.

An electric whistle is secured to the roof at each of the car and operated by a push button connection on each platform.

The trucks are of diamond frame type and while of light construction are exceptionally strong. The wheels are steel tired with a cast steel center and are free to rotate independently of each other on the stationary axle. This is accomplished by a rigid axle, upon which is pressed a nickel-steel hardened sleeve over which two trains of rollers rotate. They in turn are held in a nickel-steel hardened raceway pressed into the wide hub of the wheel.

Each car is 38 feet over the platform buffer, 8′ 3″ wide over the drip rail and 12′ 7½″ from rail to top of ventilators.

They are equipped with 220 cells A/6 Edison nickel steel Alkaline batteries, placed under the transverse seats; 200 of these are for power and 20 are for lighting and operating the multiple control relays.

Each car is equipped with four 10 H.P. 200 volt, 37.5 amperes, 800 R.P.M. series wound motors. Two motors permanently connected in multiple are suspended, one on each axle of each truck, and the wheel is driven by a gear on the inside of the wide hub through single reduction to the motor pinion.

DATA OF FIRST OFFICIAL TRIAL.

Courtesy of the Pennsylvania-Long Island Railroad Companies.

Left Pennsylvania Station, 33rd St., New York	3.12 P.M.	
Arrived at Long Beach, L. I.	4.07 P.M.	55 Mins.
Left Long Beach, L. I.	5.20 P.M.	
Arrived Pennsylvania Station, 33rd St., New York	6.14 P.M.	54 Mins.
		1 Stop

Round trip distance 49.2 miles.

Ampere hours per round trip for three car train	622	
Average voltage	220	
Train miles round trip	49.2	
Number of passengers	136	
Net weight with load	68.2	Tons
Net weight without load	58	Tons
Car miles	147.6	
Maximum running speed	42	M.P.H.
Schedule speed	27.14	M.P.H.
Number of stops	3	

Power Consumption.

(Readings on train—battery output—motors consumed.)

Three car train, round trip, 49.2 miles	136.800	K.W. Hrs.
Per train mile	2.780	" "
Per car mile	0.926	" "
Per ton mile	0.040	" "

Mileage Capacity of Train.

(On this road, with this load, at this speed.)

Note: An "overcharge" of battery—10 hrs. @ 30-60 amperes. A "normal" charge of battery—7 hrs. @ 45 amperes.

"Intermediate" charges may be given battery without undue heating as follows:

"Boosts" 5 mins. @ 5 times normal rate or at 225 amp.
"Boosts" 20 mins. @ 4 times normal rate or at 180 amp.
"Boosts" 30 mins. @ 3 times normal rate or at 135 amp.
"Boosts" 60 mins. @ 2 times normal rate or at 90 amp.

On one overcharge of battery	76.2	miles
On one normal charge of battery	65.2	"
On one normal charge of battery, plus intermediate charges aggregating 1 hour	83.8	"
On one normal charge of battery, plus intermediate charges aggregating 2 hours	102.4	"
On one normal charge of battery, plus intermediate charges aggregating 3 hours	121.0	"
On one normal charge of battery, plus intermediate charges aggregating 4 hours	139.6	"
On one normal charge of battery, plus intermediate charges aggregating 5 hours	158.2	"

Motors rated at 37.5 amp. 200 volts, 800 R.P.M. guaranteed overload capacity 100 per cent.

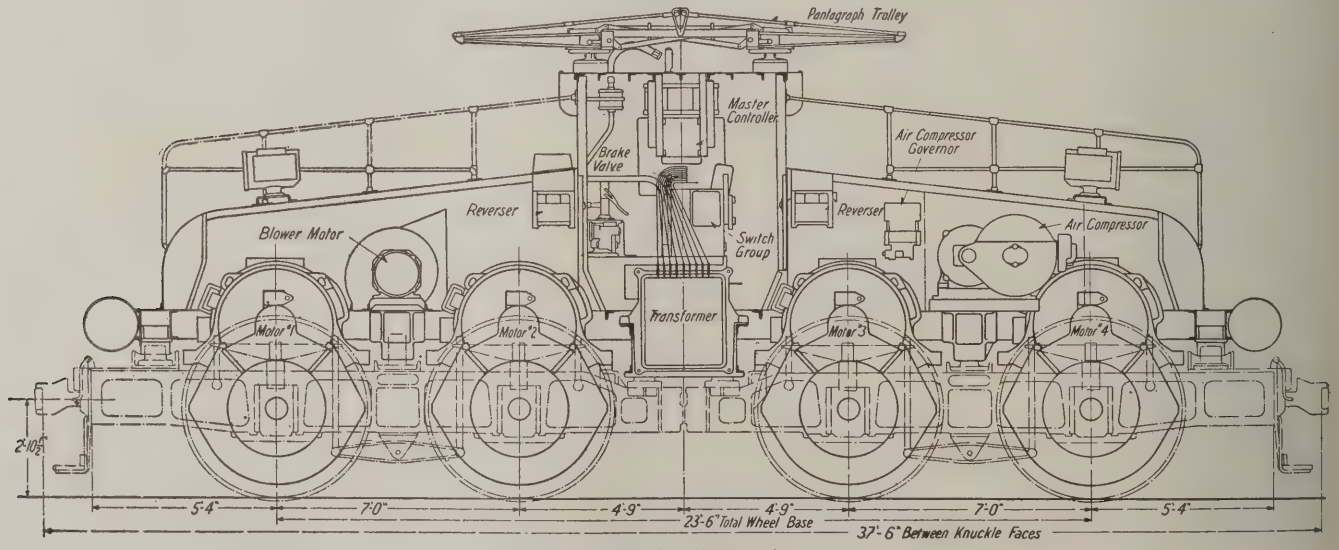
Batteries rated at 225 amp. hrs. output (1 normal charge) guaranteed overload capacity 500% charge or discharge. Batteries rated at 302 watt hours output per cell (1 normal charge) 60.4 K.W. hrs. per car, 180.200 K.W. hrs. per train.

Batteries rated at 342 watt hours output per cell (1 overcharge) 68.4 K.W. hrs. per car, 225.200 K.W. hrs. per train.

Weight of car without battery	34,100	lbs.
Weight of battery per car	4,600	lbs.
Weight of car with battery	38,700	lbs.
Number of battery cells per car for power	200	
Number of battery cells per car for lighting and operating seloid-multiple control relays	20	

New Haven Center Cab Control Switcher Locomotive

Included in the wholesale installation of electric switcher locomotives being made by the New York, New Haven & Hartford R. R. for its Harlem Yard Service, is locomotive No. 0215 Fig. 1 and 2. This locomotive is somewhat different from the fifteen other switchers in that it is arranged for center cab control. The radical difference comes in that this locomotive has but one operating and control equipment, and this is mounted in the center of the cab. Thus the engineer has but one location in the cab for operation in either direction, the same as he would have in running a steam switcher.



Detail of Switcher Locomotive.

In Fig. 1 note the suspension of the master controller from the roof. This locomotive was especially arranged in this manner to determine which was the best switch for shunting service; a double end control (duplicate operating and controlling equipments at each end of the cab) or center cab control (but one operating and controlling equipment mounted in the center of the cab).

The complete cab is of the "steeple type" with the control cab in the center, and two sloping end hoods protecting the control and auxiliary apparatus.

Articulated truck construction is used in this locomotive, the same as in others of this type. The frames are placed directly outside the wheels and are steel castings of the usual bar type, having the straight pedestals with removal gibs. The pulling and buffing strains are taken by the truck frames, which are joined at the center of the locomotive by a draw-bar. Semi-elliptic springs are placed directly over the journal boxes, and the springs of each truck are connected to equalizing bars, but no cross equalization is used. An end view of this locomotive is shown in Fig. 3.

For propelling this locomitve are used four 192-hp., 25 cycle single-phase, alternating-current, railway motors of Westinghouse manufacture. On the end of each motor armature shaft is located a pinion which meshes with a steel-rimed gear. These gears are mounted rigidly on a quill which surrounds the axle with a clearance

sufficient to allow for vertical wheel play. In the motor frame are journals formed, which carry the quills. Helical springs transmit the motor tractive effort from the gears to wheels. These springs are rigidly attached to the wheel center and gear center respectively. Thus the

Side View of Locomotive.

motors are spring-supported and the center of gravity of the locomotive is at a suitable height above the rail. A superstructure built of rolled steel shapes and plates carries the frame; the cab bolsters are of cast steel. The main driving wheels are 63 inches in diameter and have 56-inch cast steel spoke centers.

Since these locomotives are to operate only on the New Haven system no provision has been made for

End View of Locomotive.

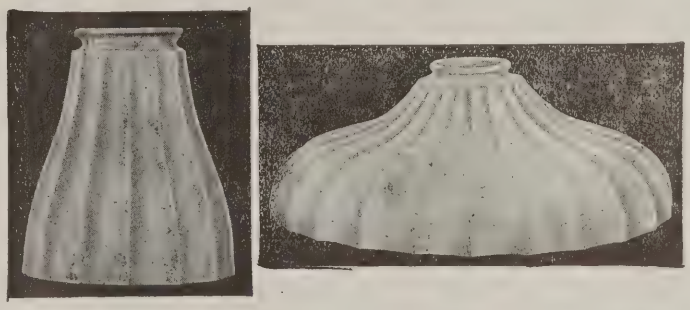
operating on direct current. Thus the control equipment is very simple; it is of Westinghouse electro-pneumatic unit switch type. In this locomotive the main circuit apparatus consists of high tension oil circuit breaker, transformer, switch group, three preventive coils and two reservers.

The auxiliary control circuit, the energization of which is determined by the movement of the master controller handle, is supplied by a 20-volt storage battery. A motor-generator set is used to charge this battery. However, usually the battery floats on the line while the motor-generator supplies the control circuit, thus in case of accident to the motor-generator set the battery is ready for immediate use.

Completely equipped this locomotive weighs 154,700 pounds. The performance of this locomotive is such that, exceptionally heavy loads can be hauled at an economical slow speed. It is capable of exerting a maximum tractive effort of 40,000 pounds up to six miles per hour.

NEW LINE OF DORIC FIXTURES.

The Jefferson Glass Company of Follansbee, W. Va., have come to realize that shade equipment for passenger cars should be not only efficient but classical in design and free from ornamentation that will collect and hold dust. With that end in view, their designers have succeeded in producing an entirely new line of shades and reflectors which are also suitable for the lighting railway offices and stations. The pattern



A 15 and a 40 watt Size Unit.

is known as the "Doric" and the illustrations will demonstrate the purity of the design, the lack of crevices being apparent. The shades need not be removed for cleaning, thus preserving the life of the lamp which suffers from handling. Their artistic de-

A Large Unit 100 to 500 Watts for Station Lighting.

sign harmonized well with the furnishings of the modern cars and they can be cleaned with the aid of a feather duster or a soft cloth.

The shades are made of the celebrated "Moonstone" diffusing glass which is free from all spots or imperfections which until the advent of this glass was considered an essential feature of diffusing glass.

This firm is also producing many original and beautiful designs for indirect and semi-indirect lighting.

They also manufacture special and novel designs in glass, in fact, the main exhibit hall of the convention of the American Electric Railway Association in Chicago, was decorated by 50 Corinthian columns measuring 8 ft. in height, 16 in. in diameter, and the top being finished with an 18 in. plain "Moonstone" ball. The entire column was illuminated by incandescant lamps. This is the first time that anything of this nature has been attempted on so large a scale. It was undoubtedly a wonderful success in every feature, and excited great comment among the practical electrical men attending this convention.

New U. S. L. Regulator

The U. S. Light & Heating Co., have recently perfected a new generator regulator, or panel, which is known as their type SI.

This panel as shown herewith has mounted upon it four pieces; the automatic switch, the generator current regulator, and the lamp regulator relay.

The lamp regulator panel may be mounted immediately below the SI panel shown below, so that the entire regulating apparatus may be installed with the lamp circuit switches in a single locker.

The automatic switch is of the original Bliss type construction which has proved so successful for the past 15 years of service.

The generator current regulator is an independent piece of apparatus and performs but one function, that of regulating the generator current. This regulator controls the generator current by means of a solenoid pull increasing or decreasing the pressure on a pile of carbon blocks in series with the generator field. Until the battery has become fully charged, this regulator will control the generator output in a manner very similar to that of the former type current regulator manufactured by this company. As the battery becomes fully charged, however, its potential will gradually raise and when this should have risen to 42 volts, the potential regulator assumes control and immediately reduces the generator voltage to 35 volts. This is the floating voltage of 16 cells of battery, so the battery charging will be discontinued. The potential regulator will hold the generator voltage constant at this value of 35 volts, regardless of what lamp load is required, and while the generator speed varies from cutting in speed up to the highest possible train speed.

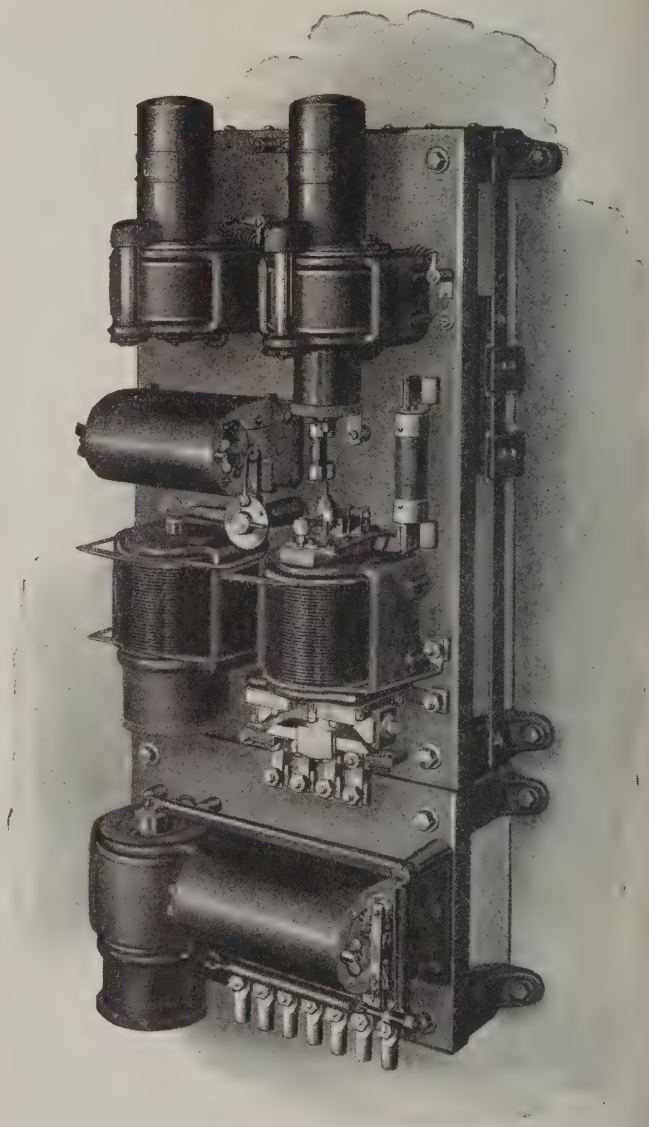
As the battery current is maintained at practically zero value by this regulator, it does not make any difference whether the battery circuit is open or closed. The regulation is just as smooth and perfect on open battery circuit as it is on closed battery circuit.

This regulator also has the property of enabling the generator to carry any lamp load that may be necessary whether the battery circuit is open or closed. Open battery circuits are an occasional source of trouble, which, on the older type equipments will cause the generator voltage to raise to such a high value that they either blow a fuse or burn out all the lamps in the car. So this feature of the new equipment will be appreciated by car lighting men.

They have also perfected a new lamp regulator which is not more than half the size of their older type. This regulator has been designed especially for use inside of railroad cars or it may be put on a frame and mounted outside in the customary manner. This lamp regulator is controlled by the Type K. relay which has been in successful operation during the past year, and which, as before stated, is mounted on the type S-I panel.

They have perfected a system of air dash pot construction and have applied air dash pots wherever they are necessary on the type S-I panel and the type B-I lamp regulator, thus eliminating all the troubles that arise from the use of oil, glycerine and other materials in dash pots.

They have also re-designed their generator to accommodate all of the standard makes of ball bearings and roller bearings, without any alteration on the machine itself.



New U. S. L. Regulator Type S-I. with Lamp Regulator Below.

They are now furnishing aluminum brush holders in all generators, as this metal lends itself readily to this work, lightens the brush mechanism and adds greatly to the appearance of the apparatus.

They have also modified the design of their combined brush rig and pole changer so as to prevent installing the same in the generator in any but the correct position. While this is a very valuable feature and one which it was very important should be incorporated they have not sacrificed interchangeability, and the new brush mechanism will interchange perfectly with the older types.

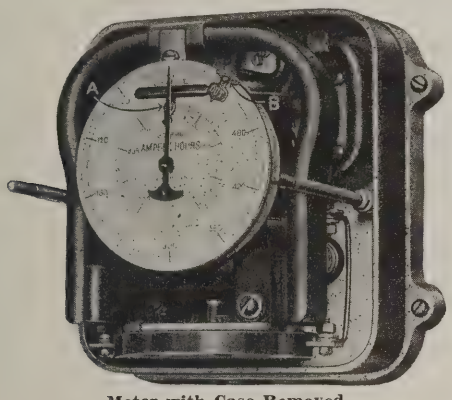
They are now using case hardened steel bushings in the eyes of all suspension links, so as to reduce the amount of wear at this point and make it easy to restore the original size of the hole without destroying or losing the links.

They have also designed, and have put into service, a self adjusting spherical tension spring seat. This accompanies all of their standard suspensions and has proved to be of great value in reducing the weight of the tension rods and the holes through the suspension bars through which the tension rods pass. They have also provided all of their space bars with swivel guides which has completely eliminated all breakage of space bar guides near the locking nuts.

Variable Resistor Type Ampere Hour Meter

The recent developments of the variable resistor type meter now makes it possible to use this meter as an absolute controlling principle for axle lighting systems.

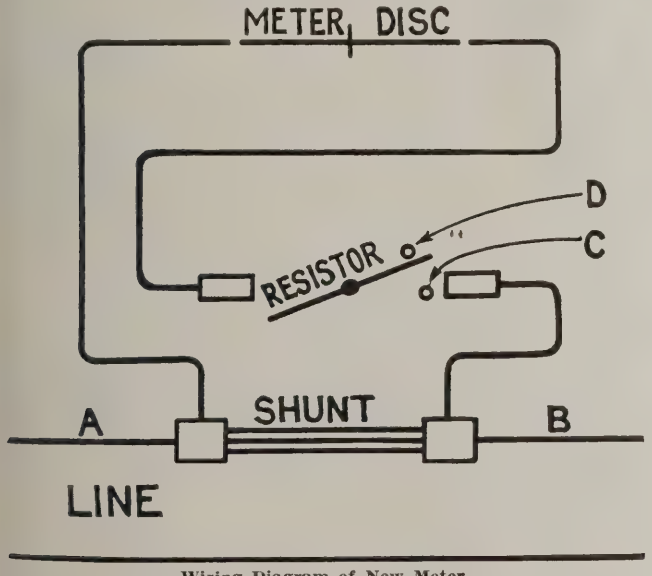
Heretofore the use of the ampere hour meter has been limited to the straight storage systems, and has only been used in connection with axle systems to give an indication of the ampere hour charge and discharge. But this



Meter with Case Removed.

new type makes it now possible to place the meter in a storage battery circuit of an axle equipment and to use it for limiting the charge which the storage battery receives.

As shown in the accompanying diagram, the motor element of the meter is placed across a shunt and the variable resistor is in series with it. This resistor is merely a copper bar placed in a sealed mercury chamber and pivoted so that it may revolve through a slight angle. This sealed element is then clamped across the magnet poles at the bottom of the meter, as shown in Fig. 2.



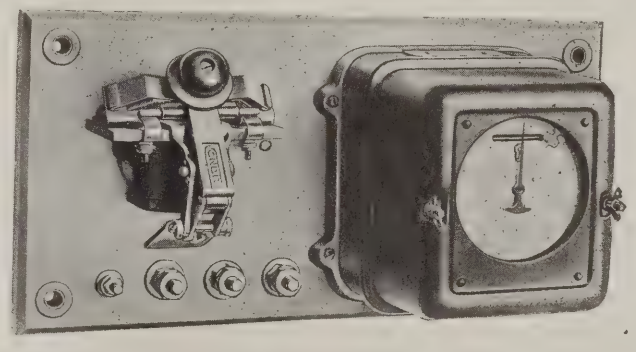
Wiring Diagram of New Meter.

When the battery is being discharged current will flow through both the shunt and meter in a direction from "A" to "B". This will cause the meter disk to revolve, registering the discharge, and the copper bar in the resistor will be in the "closed" position, touching "C", so as to provide a short path of low resistance through the resistor.

When the current flows in the charging direction, however, its direction through the meter will be reversd, flowing from "B" to "A" through both shunt and meter. The direction of rotation of the meter disc will then be reversed and the copper bar of the resistor element will tend to revolve in a reverse direction just as the meter disc does. The stop "D", however, permits it to revolve only through a slight angle, where it remains until the current again reverses. But this introduces a certain amount of mercury in the path of current flowing through the meter disc.

As mercury has about sixty times the resistance of copper, introducing even a short path of mercury in the meter circuit will considerably increase the resistance of this circuit and reduce the amount of current shunted through the meter. This will cause the meter to run slower on charge than it does on discharge and an overcharge of anywhere from 20 to 30 per cent. provided for as desired.

This meter can be employed to perform the same function in stopping battery charging when the charge has been completed as the stop charge relay was designed to do. As this meter, however, operates entirely upon an ampere hour principle, it will not be subject to the same variations and uncertainties of operation as has been experienced with the stop charge relay.



Meter with Circuit Breaker on Panel.

As the battery discharges in the terminal or at stops, the meter will record this discharge and the dial indicating the amount will revolve slowly in a clockwise direction.

Assume that when leaving the terminal the battery shows a discharge of 100 ampere hours. The axle equipment will operate normally without any interference from the ampere hour meter. During the night the battery will likely become fully charged, but in moving from 100 back to 0, the meter will run 20 per cent slower, as explained above, so that there will actually be 120 ampere hours charge put back into the battery before reaching the 0 point.

At this point, however, there is a contact "A" which may be used to close an electrical circuit and either render the generator entirely inoperative or to cause the storage batteries to merely float on the line. This condition of

no charge will be maintained until the battery has discharged a certain amount, but when the dial indicating hand reaches the point "B" it will make a restoring contact which will restore the generator axle equipment to normal operation again.

The tendency will then be to keep the storage battery nearly full at all times, yet the destructive overcharging, which has seemed to be an inherent part of axle lighting equipments up to the present time, will be entirely eliminated. The axle lighting batteries operating on the ampere hour principle with this device will then be operated very nearly as the standby batteries in street railway work are, that is, kept approximately in a floating condition, with the battery nearly charged at all times.

The long life of storage batteries operated in this standby service is an excellent indication of what may be expected from storage batteries in axle lighting service when operated on this new principle of control.

A New Speed Change System for Motor Drives

This system consists essentially of an ingenious arrangement whereby the regular cone pulleys furnished as a standard part of the lathes, shapes, milling machines, etc., are applied directly to the machine in close proximity

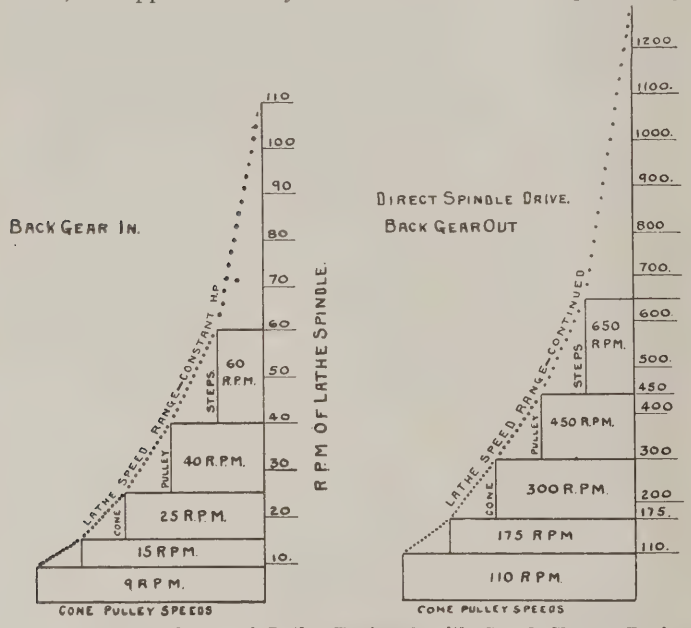


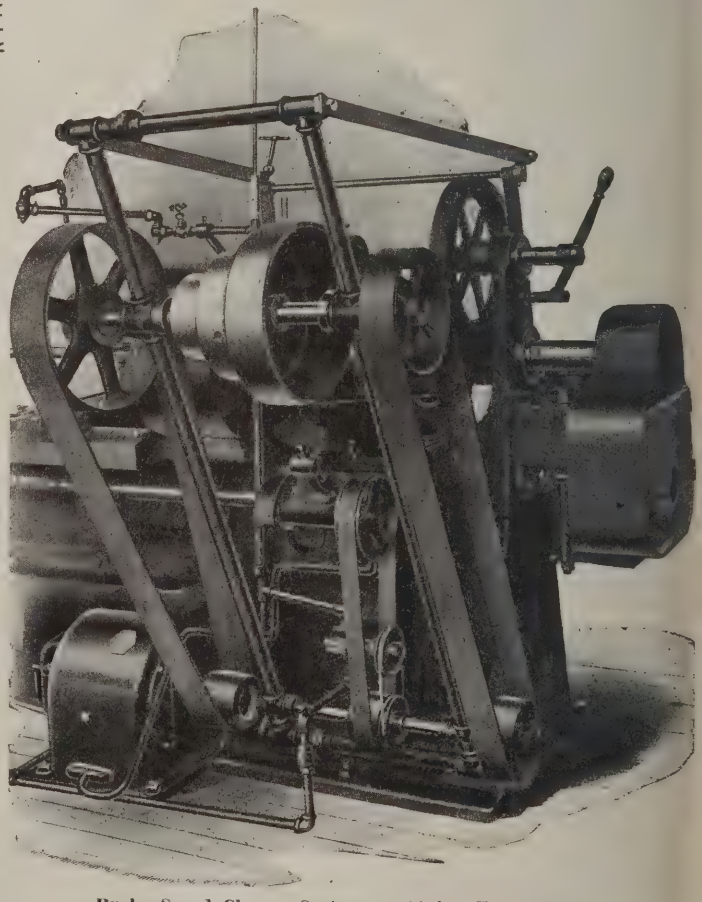
Chart Showing Speed of Lathe Equipped with Speed Change Device and Field Rheostat Control.

to them instead of being supported from side walls or ceilings. The supporting frame which holds the driving cone pulley is usually supported at one end by the motor which in turn is directly attached to the base of the machine tool and is supported at the other end through an adjustable cam joint which enables the driving cone pulleys of the machine tool through a short belt which can be tightened or loosened in an instant, so that speed adjustments are made much more rapidly than with ordinary belt drive. The belt adjustment can be varied with such ease and with such a degree of nicety as to enable the operator to run the belt loose for high speed work and tight for low speed work, and as a result of this no trouble is experienced from hot bearings or unusual wear on the journal boxes.

The system affords every advantage offered by individual electric motor drive with the use of either alternating or direct current motors and at the same time affords all the well known and desirable features of belt drive.

In addition to its advantages when viewed from an operating standpoint, it is reported as less expensive to install than almost any other system, the reason being that it employs standard constant speed motors and can usually accomodate alternating current motors at speeds of 900 and 1200 RPM, whereas with any of the other systems of securing speed adjustment in the motors, whether A. C. or D. C., the motors must be made large enough to deliver their rated horse power at the lowest speed and therefore the motors become considerably more expensive. Furthermore, it is readily seen that by this system motors can be applied to existing machine tools as well as to new ones. The advantage is of great value to those railroad shops where the machine tools were installed before the many advantages of electric motor drive were fully appreciated, or where electric power could not be had at the time the machine tools were put in, but where electricity has since become available for use throughout the shop, so that all that is now needed is the application of a speed change device of this kind to enable the machine tools to be driven directly by individual motors.

In connection with the cost of installing this system the following comparative figures were recently obtained in connection with equipping two 21" Gisholt turret lathes of identical pattern, one with an adjustable speed 4 to 1 range direct current motor and the other with an adjustable 1½ to 1 range direct current motor with

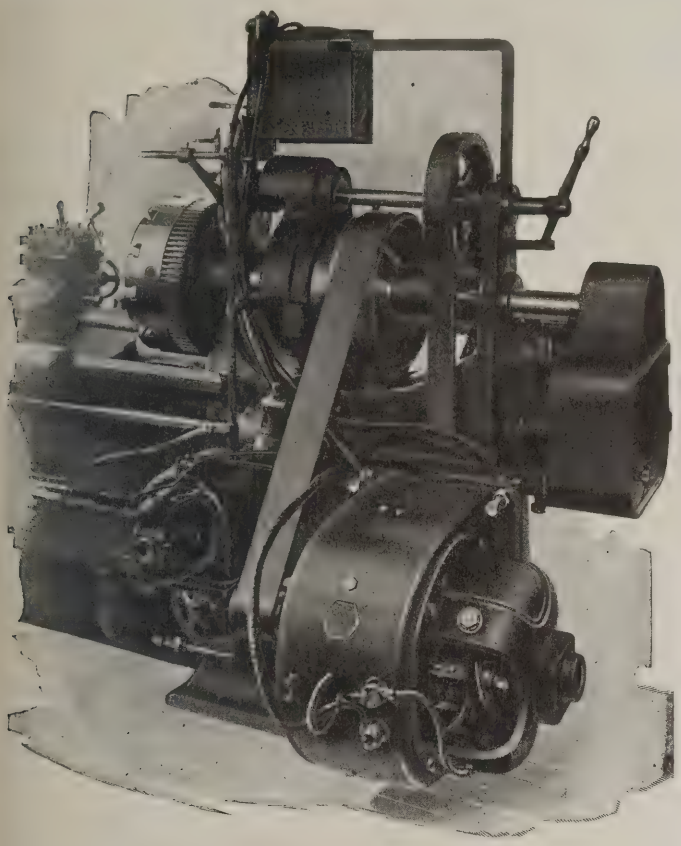


Burke Speed Change System on 21 in. Turret Lathe.

Burke Electric Company Speed Change Device. The motor applications are shown in the accompanying half tones and the figures are as follows:

Two Motor Drive.

1 3½ H. P., 4:1 motor;
1 1 H. P., constant speed motor: 1 Combined starter and controller;
Total cost $204.00



Variable Speed Motor on 21 in. Turret Lathe.

Extra charge above price of standard belted lathe for motor drive including equipment except motors and wiring $250.00

Net cost $454.00

Single Motors and Burke Electric Company Speed Change Device

1 4 H. P., 1 1-12 1 motor and controller with Speed Change Device $213.00

Less credit for counter-shaft, two hangers, high speed pulley and reverse speed pulley (Cone pulley and one driving pulley were kept)....$ 25.00

Net cost $188.00

Saving effected by using Burke Electric Company Speed Change System exclusive of saving in wiring $266.00

While the great advantage of this system is in its ability to permit of applying standard speed A. C., motors directly to standard machine tools, yet where direct current is available a finer range of speed adjustment can be obtained than with any other motor drive system employing field weakening motors. The two diagrams shown herewith illustrate very well the remarkably wide speed range and great number of speed adjustments which are possible with this equipment. The chart was obtained from a standard lathe which was already equipped with a five step cone pulley and to which this speed change device had been applied in connection with a 2:1 adjustable speed interpole motor with field rheostat controller. Each dot in the diagram represents a motor speed filling the gaps between the cone speeds, and illustrates a practically uniform change of speed of the lathe spindle from 9 RPM to 1255 RPM.

This speed change device apparently solves the big problem of providing for variable speed adjustment of motors applied directly to machine tools with an alternating current shop installation and removes the last argument against the universal use of alternating current motors in railway shop practice. The system retains all the advantages of belt drive and belt flexibility, yet at the same time does away with the mass of overhead belting and excessive transmission losses where line shafting used.

This speed charge device is manufactured by the Burke Electric Co. of Erie, Pa.

*These are a part of the standard belted machines outfit, but are not needed with this system of motor drive.

I. C. R. R. EDUCATES ITS MEN.

With all our political frenzy to conserve the natural resources of our country so that our posterity may share in their riches, we are overlooking and neglecting the proper training of the youth of this generation so that when the estate of manhood and womanhood is reached, they may start the game of life unhandicapped.

Realizing that capable men, rank and file as well as the staff, are a necessity to the good conduct and economical operation of the transportation line, Mr. W. L. Park, Vice-President of the Illinois Central Railroad, established two years ago an Educational Bureau, the instruction being very largely conducted by correspondence.

The curriculum includes thirty-two courses, the most prominent of which are:

Block Signals and Inter-Locking.
Railroad Operation.
Locomotive.
Air Brake.
Gas Engine.
Mechanical Drawing.
Railway Mechanical Engineering.
Boiler.
Track.
Surveying and Mapping.
Railway Civil Engineering.
Freight and Passenger Traffic.
Railway Accounting.
Telegraph and Telephone.
Electric Light and Power.
Etc., etc., etc.

The accruing benefits, both to the students and the railroad, have been demonstrated to be great. Over four thousand employes, distributed through all departments, are enrolled, and the markings of their papers indicate satisfactory progress.

AMERICAN PULLEY CO. INCREASES PLANT.

The American Pulley Company, in order to keep more closely in touch with large and growing trade requirements, is increasing its productive capacity by the erection of a new concrete warehouse addition to its present plant on Wissahickon avenue, with a basement and main floor, each having an extent of 22,000 square feet of floor space—the new building will also contain a large new second-story office, the old office structure being diverted to the extension of the machine shops—a substantial evidence of the company's constantly enhancing success and prosperity.

Lesson No. 9.

Belts and How to Apply Them

Probably the most abused part of an axle system is the belt. It is placed down under the car where it is inconvenient to work at and hard to inspect properly, and at the same time encounters very severe conditions particularly in the winter time when ice and snow often completely cover machine, suspension, pulley and everything else.

We realized before we started this lesson, that no matter what fine theoretical ideas a man may have, it is pretty hard to put these into practice when it comes to the car lighting belt. But we hope to show first, how to line up a generator properly; second, how to apply a belt with fastener; third, what is the proper tension to pull a certain load; fourth, how to tell when you have the belt adjusted to that tension.

In our August lesson we explained how to properly line up a generator and axle pulley, and just touched on the subject of belts. Please refer to that and read it again.

There are three different kinds of belts used in car lighting service; the rubber belt, the balata belt, and the cotton stitched belt.

The rubber belt is made up of four or five layers of heavy canvass which is thoroughly impregnated with a rubber compound under hydraulic pressure combined with a vulcanizing process. This causes the rubber to enter into all the pores of the canvass, causing the layers to stick firmly together.

When a belt runs over an armature pulley, there is a tendency for the layers of canvass to slide over each other, so it is very important that the rubber penetrate the layers of canvass thoroughly and bind them together solidly.

The balata belt is made somewhat similar to the rubber belt, except that instead of a rubber compound being used, balata gum, which has different characteristics from rubber is used.

Balata gum comes from a tropical tree as crude rubber does. It resists both water and oils and gives excellent wearing service.

There are numerous stitched cotton belts impregnated with various waterproof compounds, and these are made up very similar to the balata and rubber belts, being composed of four or five layers of canvass stitched together, the whole being impregnated with compound while the belt is under tension.

APPLYING THE BELT.

Every road should endeavor to standardize diameters of axle and armature pulleys and generator suspensions so that there may be only two different lengths of belt required; one for a 17 in. axle pulley, and one for a 21 in. axle pulley. (The 21 in. axle pulley with a 12 in. or 14 in. armature pulley should be used whenever possible, as with this combination the internal grinding of the layers of a belt as it engages the pulley is considerably less than with an 8 in. armature pulley.)

Where it is possible the belts should be cut in the shop and fastener applied to one end. It's a good deal easier to do an accurate and careful job in the shop than it is out in the yard under a car particularly with the thermometer at about 20 below.

Some men have an idea that a piece of belting can be hacked off most any old way, but as a matter of fact, it is a pretty important job and men should have a good heavy, sharp knife and cut the belt off with a number of strokes of the knife, and with a steel square to guide it. *Don't try to cut all the way through the belt on the first stroke.*

The Crescent Fastener.

This should be applied to one end of the belt in the shop. Lay the belt over a wooden block and set the clamp down squarely with ½ in. projecting over the end. Drive the clinch rivets in plumb, and with the sharp point set lengthwise of the belt so that they will not cut any of the tension fibers of the canvass. Then turn the belt over and spread the clinches of the rivets down, laying a steel rod about ¼ in. in diameter between the clenches and strike it lightly with a hammer. Then clinch the rivets solid but don't strike them so hard that they cut into the fibre of the belt.

Several roads are using rivets that are too long. These should not be over 3/16 in. longer than the thickness of a belt. A 3/16 in. belt will require a ⅜ in. rivet, etc. When extra long rivets are used, they project too far through the belt and when pounded down are apt to wear down to the knife edge. A short rivet will have just as great holding power, if not greater, than a long one and will not cut the belt as a long one may.

As a matter of fact, after the rivets of a Crescent fastener are properly set they all taper slightly toward the joint, so that when the tension is applied to the belt, the slight slant of the rivets causes the belt to bear over the entire length of the rivet; in fact, tends to hug the fastener, instead of the strain coming on the ends of the rivets.

To apply the belt to the car, fish the belt back over the axle pulley and bring the ends together over the armature pulley. Line up the edges carefully and bring the ends solid together, and then drive in the rivets tapering slightly away from the joint, so that when they clinch tight they pull the joint solid together.

And again, be careful that the sharpened prongs of the rivets are set so that they do not cut any of the belt fibres running lengthwise of the belt.

If the armature pulley is perforated move the joint slightly and clinch again so as to be sure that ll rivets are properly clinched.

It is particularly important to clinch these rivets in the same careful manner as is done in the shop, but if the rivets are driven so that they do not taper sideways, there is enough bevel to the prongs to cause them to spread and clinch properly when merely driven against a flat surface of the pulley.

The Alligator Fastener.

This is the new fastener which was fully described in an article on page 35 of the June 1912 issue of the *Railway Electrical Engineer.*

When belts are cut to a standard length, the two halves of this fastener may be fastened to each end of the belt in the shop. To apply the fastener take off the proper number of teeth to accommodate the belt used, and insert the belt between the jaws of the fastener with the bar side of the fastener up. Slip the gauge pin in the loops and bring up solid against the end of the belt. Start the two outside teeth first with a blow from a hammer and keep the loop and gauge pin solid against the end of the belt. Then start the middle teeth of the fastener, after which all teeth are driven half way through. Turn belt and drive prongs down until points of teeth from opposite side show through. Turn belt back, place on wood and drive prongs of both sides through as far as possible, clinching points over, after which fastener is placed on a steel block and all teeth securely pounded down.

To apply to the car, fish the belt over the axle pulley as above, and slip in the rocker hinge pin, after which the belt is brought up to proper tension by the generator takeup.

It should be noted that the rocker pin is made up of two parts with corrugations on the outer face of each. These corrugations are supposed to fit in between the loops and keep the pin from working out. Before inserting the pin see that the projections on one pin are opposite the indentations on the other where the ends are even.

The Consolidated Spring Belt Fastener.

This is another new fastener which was described on page 76 of the August issue of the *Railway Electrical Engineer*. The joint where the ends of the belt come together is cut in a "V" shape. For this fastener the manfacturer supplies an adjustable marking and cutting gauge with which the belt can be cut to proper "V," and the holes for the rivets of the springs punched at the proper place. After punching the holes, they should be countersunk on the under side enough to let the rivet head come slightly below the face of the belt. The seven springs may be riveted to one end of the belt in the shop. *Do not put washers between springs and the belt.*

To apply to a machine, slip the belt in place, and a belt crab may be used to draw the ends of the belt together when necessary. Rivet the springs in place as mentioned above. The takeup rod of the generator should be adjusted until the spring joint opens about ½ in. between the ends. When this space is reduced to about ¼ in., due to the stretch of the belt, the generator should be readjusted to the original ½ in. opening. The manufacturer supplies a complete set of marking and riveting tools.

ADJUSTING THE BELT TO PROPER TENSION.

When it comes to adjusting the belt to proper tension, the average man is pretty well up against it. In the first place he does not know what that tension should be; and in the second place, even if he did know, he wouldn't know when he had it right.

We have worked a series of curves shown herewith, which give the actual pull in lbs. necessary to deliver a certain amount of power at train speeds varying from 15 miles per hour to 80 miles per hour.

These curves show the theoretical belt pull required to deliver a certain k. w. output of the generator at the various speeds. It will be noticed that in each case the belt pull decreased as the belt increased, but if you stop to think of it, that is just what you expect, for the power delivered to the armature is the product of speed times pull, and if the speed goes up, the pull must go down if the power delivered is maintained constant.

This belt pull, however, should not be confused with the belt tension given the belt when it is applied to a generator. This is considerably greater than the belt

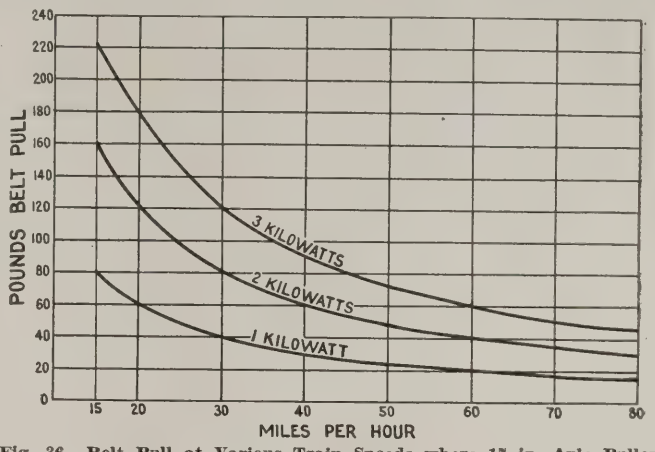


Fig. 36. Belt Pull at Various Train Speeds where 17 in. Axle Pulley is Used.

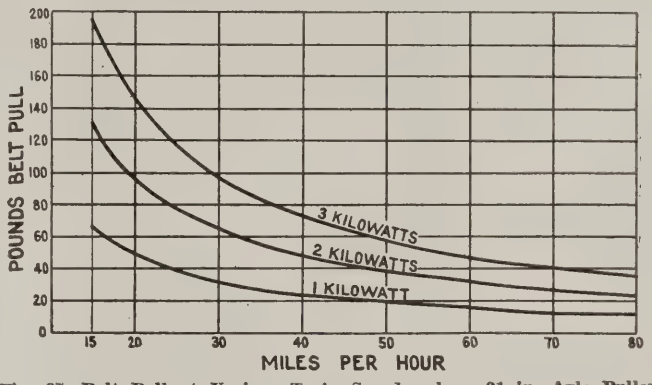


Fig. 37. Belt Pull at Various Train Speeds where 21 in. Axle Pulley is Used.

pull found on these curves. This information however, will be found very useful in estimating the proper tension which should be given a belt when applying it to a car.

Table 1.

	Maximum Driving Pull.
17 in. axle pulley.	
1 k.w.	80 lbs.
2 k.w.	160 lbs.
3 k.w.	240 lbs.
21 in. axle pulley.	
1 k.w.	65 lbs.
2 k.w.	130 lbs.
3 k.w.	195 lbs.

The above values are based on a cutting in speed of 15 miles per hour.

The above curves show the maximum pull which the belt must deliver to the armature. The problem of the axle generator man is to bring up the belt tension until it will just nicely keep the belt from slipping under this load. Now if the machine will require a maximum pull of 240 lbs. you must give the belt enough tension so that you cannot turn the armature pulley when you give it a twist of 240 lbs. It must not be so tight however, that you cannot slip it with say a twist of 300 lbs.

But now the big question is, how are you going to tell whether you give it a twist of 240 or 300 lbs? The answer is: *Practice up on it.*

But now as to details on this practice stunt. It will be a good scheme to rig up an armature shaft with a standard pulley on the end of it and mount this about

2 ft. from the floor, this being about the average height of an axle pulley above the ground. Attach a spring balance to the face of the pulley either by means of a wire or small section of a belt as shown in the accompanying illustration. Practice up on this until you know what a 100 lb. twist means, what a 200 lb. twist means, and what a 300 lb. twist means.

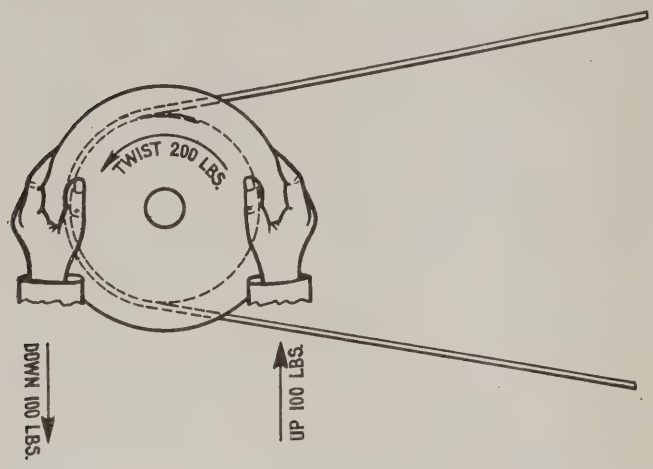


Fig. 38. Showing an Easy Way of Adjusting a Belt to Approximately the Right Tension.

Remember that a 200 lb. twist takes a 100 lb. push up on one side and a 200 lb. pull down on the other side of the pulley, as shown in Fig. 38.

Then when you apply a belt you will be able to adjust it at least within these limits and possibly much

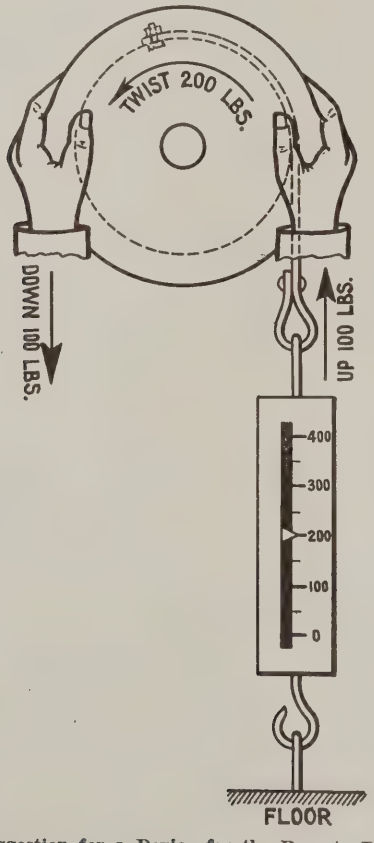


Fig. 39. Suggestion for a Device for the Boys to Practice Up On.

closer, but at any rate the belts you apply should not be pulled up two or three times as tight as they need to be.

This matter of proper adjustment of belt pull is a very important one. Belts cost from $4.00 to $5.00 a piece, and when these are carelessly applied, screwing the belt up to an extremely high tension, the first trip out often either tears a belt to pieces or the side pressure on the bearings becomes so great as to run a hot box or let the armature right down on the generator fields.

$10.00 REWARD.

Now we are going to offer a competitive prize of $10.00 to the man who can adjust a generator belt the nearest to proper value to deliver a 1, 2 and a 3 k. w. output of the generator without slipping.

This test will be run in the booth of the U. S. Light and Heating Co. during the coming convention of the Association of Railway Electrical Engineers, and is open to all car lighting boys interested.

Come along and win the prize and get the glory of being the best belt man in the country.

Practical Stunts.

Send in your ideas. We pay for them.

Testing Battery Tanks.

Where lead tanks are used for storage batteries in car lighting service, you occasionally have a small leak in a tank which will only show up when the battery is in service with the electrolyte at a high temperature.

I find the best way to test for small leaks, is to first take out the elements and after thoroughly cleansing the tank fill it up with water at 212 degree's fahr, and as the water cools draw it off and refill with hot water repeating the opperation two or three times. This causes the lead to heat up and expand, and also warms up the compound which seals the tanks in the crates, and if the leak is caused by a small crack or flaw in the lead you will most surely find it. Where if you use cold water for testing, it chills the sealing compound and tends to stop the leak. Hot water for testing tanks can be had off a locomotive in any railroad yard.

Joe Piland, L. & N. Ry.

To the Editor:—When a commutator is rough or sparking from high mica or other cause and no time or facilities to put it in lathe, by motoring generator with full field or at slow speed and grinding commutator with a piece of soft sandstone finishing with No. 00 sandpaper it will make as good a job as putting in a lathe.

A. P. R. R. Electrician.

Question Box.

Question. I operate a 60 volt headend system with three batteries on the train and the other morning, when the engineer shut off the steam on me, the underload circuit breaker didn't act and the batteries motored the generator for several seconds before I opened the switch. When I started up my machine the next night and threw in the main switch, the overload circuit breaker went out with a bang and I found that my generator voltage was reversed. I shut down the machine, put battery current through the field in the right direction and started up again with everything O. K.—But what made the machine reverse.

J. W. B.

Answer. When your steam was shut off, and the turbine was motored by storage battery current, your machine began pumping steam back into the engine, or at least tried to, with a heavy current flowing from your battery line. In fact, this would be almost equivalent to a short circuit on the line.

The voltage across the terminals of the generator was probably very low, so that the generator shunt field was

weak. Since the current flow from the battery to the generator would pass through the series compound field winding in the reverse direction from normal, and this, together with the high armature reaction of the heavy current flowing through the armature, undoubtedly reversed the generator field. When you opened up the switch, the field was left in a slightly reversed condition, any electro magnet will retain some of its magnetism even after the magnetizing current is turned off. When you started up the next night, this small amount of residual magnetism in the generator field caused generator to build up in the reverse direction, and when you closed circuit you had the negative machine connected to the positive battery and this caused both generator and battery to short circuit right through each other.

Editor.

To the Editor:—

In your February lesson Mr. Cutting suggests a scheme for reducing the voltage of a 110 volt circuit so as to light 60 volt train line from the 110 volt station circuits while the train was in the terminals by introducing a dozen cells of storage battery in circuit.

He states that these cells would buck down the voltage to a proper value regardless of how many lamps were being used.

Now as I understand it, a battery doesn't have any counter electro motive force, and it is of mighty low resistance, so the voltage on the train lines would depend altogether upon how many lamps were being used, and what the train load in amperes amounted to.

Then too, the battery capacity would have to be large enough to handle the whole train line current. I don't see that any worn out battery such as he speaks of would hold the voltage constant at all.

R. J. D.

Answer. Mr. Cutting is right in this matter, and I suggest that you stop to consider that each cell of a storage battery is like a little booster, the one helping the other to boost up the voltage of a group to a certain value. Now, if one of these cells in the battery becomes reversed, it will buck 2 volts instead of boosting 2 volts. The amount of this bucking or boosting voltage of each cell will vary somewhat of course, with the amount of current flowing, and with a heavy train line current of probably 100 amperes going through an old worn out battery as Mr. Cutting used, the voltage may be as high as 3 volts per cell

If you have a 64 volt battery fully charged and add an additional cell to it which is connected up wrong, i. e. positive pole of the battery connected to positive pole of the pulley, the effective voltage of the outfit would be 61 or 62 volts. If 2 reversed cells were added, the effective voltage might be from 58 to 60 volts.

You note from Mr. Cuttings article that he connected in 12 cells so as to buck down line voltage from 110 volts to 64 volts. This may look like a rather small number of cells, but if you will note he mentions the fact that the cells were rather old, and when operated in the train line were really being charged at high rate all the time, maybe 75 to 125 amperes depending upon the size of train line.

Under these conditions the cells might take a charging voltage of probably 3 volts which would buck the line voltage down to 74 volts. You undoubtedly have had enough experience with head-end systems to know that 74 volts on a loop will give about 64 volts on the lamps. The counter electro motive force of the battery is the important consideration here, not its internal resistance.

To the Editor:—Being employed as a batteryman and a reader of your journal I would like to secure a little information on a lead train lighting cell. Can you tell me what kills the acid when postive plate becomes buckled and shorted to negative. As a rule when the above mentioned takes place that is what I find.

On the other hand I find that sometimes the acid is not dead when same takes place. If the last mentioned be true, and I think on investigation you will find is, how long after same has been shorted is it before the acid will be dead or less than 1,150 Spec Gravity?

Harvey Davies.

Answer. The first point I wish to make clear in answer to the above is that a "short" may be anything from a tiny tree formation of lead between plates which would discharge the battery slowly, to a heavy "short" caused by buckling, or a heavy tree formation. In the first place it might take hours to fully discharge the battery or to "kill the acid" as you say, while with a heavy "short" it might do the business in half an hour, so you see it depends upon both the size of the short circuit and how long the cell has been short circuited as to what condition the acid is.

Editor.

To the Editor:—Why is there one more negative plate than positive plates in train lighting cells?

H. D.

Answer. This is done so that the full capacity of the outside positive plate may be available. If the same number of negatives as positives are used, the outside plate on one side would be negative and on the other side a positive plate. The active material on the outside face of this positive plate could not be used, as there would be no negative plate opposite it to make use of this capacity.

(*Continued next month.*)

CHARLES O. BAKER JOINS THE GOULD COMPANY.

Mr. Chas. O. Baker formerly Manager of the Wheeler Reflector Co., of Boston, has very recently become connected with the Gould Coupler Co., and the Gould Storage Battery Company.

We are glad to welcome Mr. Baker to a more intimate connection with the car lighting field, and feel that his wide experience in the design and manufacture of reflectors for industrial purposes will make him an active and valuable member in Association as well as in general railway work.

NEW LAVIATHAN BELTING.

After a rather extensive investigation as to the special requirements of railway car lighting service, the Main Belting Company of Philadelphia have designed a new laviathan car lighting belt. This belt is made of four or five plys, as desired, of the best grade of cotton duck belting, thoroughly impregnated into the very fibers with a material especially designed to withstand heat, cold, dust, dirt, water, snow, etc.

This compound is applied while the belt is under tension so that the stretch is almost entirely eliminated. Manufacturers state that the first samples of this new belt were applied November, 1911, and that experience has shown that the ordinary generator take-up is sufficient to allow for all belt stretch.

This new belt is shown in an operating exhibit at booth 60 at the Convention, 9th floor, Auditorium Hotel.

A NEW X-RAY PRODUCT.

Here is a new X-Ray Reflector intended for drop cord and bench lighting in shops, over counters and work tables, for all kinds of localized lighting, and for general illumination from comparatively low ceilings, as, for instance, bowling alleys, basements, store rooms and corridors.

New X-Ray Reflector.

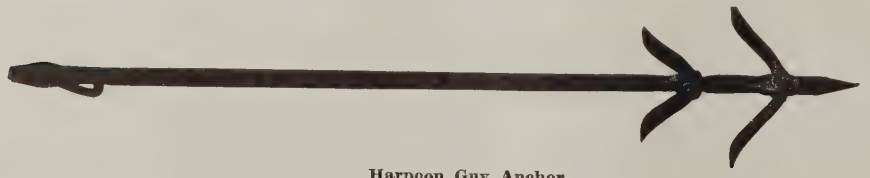
It is constructed of glass in one piece. The vertical and spiral corrugations produce an almost perfect diffusion. A coating of elastic enamel protects the silvered reflecting surface from cracking and deterioration.

This X-Ray Reflector meets a demand for a distributing type of reflector for 25-watt and 40-watt Mazda lamps. At 30° from the vertical, with a 40-watt lamp, No. 555 delivers 94 apparent candle power. The reflector is 6⅜" in diameter and 5⅛" high. It is manufactured by the National X-Ray Reflector Co. of Chicago.

"A SLEDGE AND A MAN TO SWING IT."

In these days of hurry and hustle, the time and labor saver, other qualities being equal, is first choice in all lines of industry. Thus a guy anchor that can be installed by one man in ten minutes is preferred to another that requires the services of two men for a longer period of time.

This remarkable short time of ten minutes is claimed by the Crouse-Hinds Company as the average for sinking and setting its Harpoon Guy Anchor. It is further claimed that the "Harpoon" can be installed quickly where intertwining roots, buried timber or other obstructions preclude or make exceedingly difficult the location of other forms of patent anchors.



Harpoon Guy Anchor.

All parts of the Harpoon Guy Anchor are made of steel, three sections being used as each proved itself best adapted for the particular purpose. The point of the rod is hardened and, without injury to itself, will chip off or turn aside such large stones as may be in the anchor's path.

"A sledge and a man to swing it" is the catch phrase of the manufacturer, in declaring the full requirement for driving the "Harpoon"—driving, not burying or screwing in—, and an upward pull, such as could be given by the tightening of the guy wire, sets it. This pull causes the four wings to open out in undisturbed ground.

A handsome catalogue, containing full data regarding the Harpoon Guy Anchor and numerous illustrated solutions of troublesome anchorage problems can be secured free by writing to the Crouse-Hinds Co., Syracuse, N. Y.

CRAVENS ELECTRIC CO.

Announcement is made of the removal of the offices of the Cravens Electric Company from the Commercial National Bank Building to 12-14 S. Jefferson street, Chicago. This change is made necessary by the rapidly growing business of the company. A large new shop has been equipped, which, together with the location of the offices in the same building permits the company to maintain its reputation for very prompt shipments.

HESS-BRIGHT MOVES TO NEW FACTORY.

The new factory and office of the Hess-Bright Manufacturing Co., at Front Street and Erie Avenue, Philadelphia, Pa., has a frontage of 200 feet and a depth of 235 feet. The entire second floor to a depth of 35 feet is devoted to offices. Back of the offices the building is one story high with sawtooth roof. The bulk of the Company's product is imported, and the output of the new shops here shown will represent but a very small proportion of the entire business done. The present building forms the nucleus of a much larger plant which it is intended eventually to erect.

NEW BENJAMIN CATALOGUE.

A new catalogue on lighting specialties has just been issued by the Benjamin Electric & Manufacturing Company of Chicago. It contains a complete line of information regarding wireless clusters, sockets, reflectors for industrial and shop illumination, outdoor lighting fixtures and numerous Benjamin specialties such as their new spring clamp shade holder, new lamp grip, attachment plug, lock guards for reflectors, etc.

AMPERE HOUR METER BULLETIN.

The Sangamo Electric Co., of Springfield, Ill., is distributing a 24-page booklet on the use of ampere hour meters in connection with storage batteries. Although the bulletin relates more particularly to vehicle batteries, it contains much of interest and value to railway car lighting men.

In addition to a description of several of the newest types of ampere hour meters, it contains considerable information on the most approved storage battery practice.

Write for one of these bulletins if you have not already received one.

POSITION WANTED.

POSITION WANTED—By a man having 2½ years experience in both axle generator and battery work, thoroughly familiar with Bliss, Gould, Safety and Consolidated systems. Has technical education acquired by home study, competent to take charge of the electrical work at a terminal, and is now employed in car lighting work. W. B. H., care Railway Electrical Engineer.

POSITION WANTED—By one who has had 8 years of experience in looking after Electrical Lighted Cars and all kind of equipment and Head End System. Reply in care of Electrical Engineer. Address E. W. M. Railway Electrical Engineer.

WANTED—A man to learn automobile starter and lighter inspection work. One familiar with car lighting prefered. Apply at No. 3854 Lancaster Ave., Philadelphia, Penn., and furnish reference: U. S. Light & Heating Co.

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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Fifth Annual Convention.

The fifth annual convention of the Association of Railway Electrical Engineers last month while being greater both in points of number of men attending and size and value of the exhibits gave marked evidence of the broadening of the scope and purposes of the Association as shown by the character of the papers and their accompanying discussion.

The paper on Electrification of Trunk Lines by Mr. N. W. Storer contained much information on the development of electric equipments for railroad operation and brought forth much interesting discussion from railroad men present.

The paper on steam turbines by Mr. W. J. A. London and Mr. A. P. Peck and the instructive discussion which followed showed that this Association is fully alive to the requirements and possibilities of power plant design for railroad shops and terminals.

The paper on Industrial Lighting by Mr. B. F. Fisher though of a non-technical nature was very instructive.

The report o fthe committee on Shap Practice both contained much valuable information and recommendations for standard practice and drew forth a lively discussion on shop problems.

The talk by Mr. A. J. Sweet on postal car lighting covered an extremely live subject in a comprehensive way. The postal authorities are now drawing up specifications for postal cars, so the report of a recent investigation of this subject which formed the basis of Mr. Sweet's talk was most timely.

Mr. Read, Chairman of the Committee on Standard Postal Car Construction attended the convention and discussed this subject.

The Committee on Specifications reported on belts for car lighting, incandescent lamps for car lighting, and wire. The last part of their report referring to wire was of a most comprehensive nature in fact this is the first attempt on the part of any purchaser of wire to draw up anything like a complete specification which would cover every case.

The Committee on Train Lighting Practice and the other standing committees of the association contained much information of real value. This is all briefly abstracted in this issue.

Light, Its Use and Misuse.

The Illuminating Engineering Societty have just issued a primer on illumination which is written specially for the general public.

Illumination is probably one of the most abused arts or sciences which the public tries to employ for its own comfort and convenience. Mistaken ideas as to what is good and effective illumination are so prevalent that this primer as published by the Illumination Engineering Society will meet a long felt need in the education of the general public along this line.

We believe this primer will be of such interest and value to all railroad men that we are warranted in repairing hrdl mfwy mfwyp mfwyp bgkq bgk bgkqjj reprinting the pamphlet entire. The first section of this is published in this issue. The balance will appear in our December and January issues.

Electric Headlights.

The series of tests, made by the Railroad Commission of Wisconsin recently, the results of which were presented before the October meeting of the Western Railway Club contains much interesting information. As in a similar series of tests made by Dean Benjamin of Purdue University in 1909, it was found that the number of false or phantom signals which were observed were surprisingly large, in fact the proportion of signals incorrectly observed was so large that if the same difficulty were experienced by locomotive engineers operating the electric head light in practical service there would be a larger number of wrecks every night. This paper is abstracted later in this issue from which some of the important details may be obtained.

As a general thing we are still using some old oil head lights that we did 50 years ago and as a matter of fact if anything, this oil head light has deteriorated instead of improving in that time. The claim is made that the air brake is the greatest safety appliance in modern railroading but of what use is it at night if we do not have a light which makes if possible to see objects on the right of way.

The main source of disagreement as to the best headlight seems to be largely due to a misunderstanding of or disagreement as to the functions of that headlight. Some of the railroads may take the position that the head light is the mere front end marker and is not intended to illuminate the track or objects nearby. The other

group takes the position that besides being a front end marker the headlight is intended to illuminate the track and objects near it so that the engineer may observe them and the pedestrian or man in a vehicle about to cross the track may see the beam of light of an approaching train.

The difficulty with the electric headlight seems to be in causing phantom signals, blinding the approaching engineer or switchman in front and making it difficult to read the classification signals on the front of an engine.

Locomotive engineers who have used electric headlights stated that while they receive phantom signals occasionaly they can readily distinguish these from the true signal light. Moreover it is usually possible to read the position of the signal arm as is done in day light. Practically all of the electric headlights are now equipped with an incandescent lamp auxiliary which is to be used in terminals and when approaching an opposing engine.

The mere fact that there are over 20,000 electric headlights in service with little or no trouble from phantom signal lights or classification signals would indicate that there was something fundamentally wrong about the investigation carried on by both the Railroad Commission of Wisconsin and by Dean Benjamin for the Indiana Railroad Commission. It is probably due to the fact that the observers included few if any practical locomotive engineers having had long experience with the electric headlights. As pointed out by Prof. Mack, a blacksmith can tell the color of a piece of steel in the fire while an inexperienced man is blinded by the glare of the surrounding coals.

It is unfortunate too, inasmuch as both commissions found the light of the electric arc to be too intense, that some of the types of electric headlights of a candle power midway between that of the oil and the present high power arc light were not also tested.

Fifth Annual Convention of the Association of Railway Electrical Engineers.

The Association of Railway Electrical Engineers was called to order by President F. R. Frost, Elecrical Engineer of the Sante Fe, at 10 A. M. Tuesday, October 22nd in the Assembly Hall of the Auditorium Hotel, Chicago. President Frost then addressed the Association as follows:—

The record of railway electrical engineering during the past year has been eventful and progressive along many lines. In car lighting sixty volts has been made standard for practical all "head end" service: new types of current regulators for axle devices have been brought out, giving greater adaptability to changing service conditions and the larger use of ball bearings in dynamos and further investigation of belt drive have improved axle lighting service: new arrangements of conduit and design of special fittings have simplified conduit systems and made it practicable to install car wiring in accordance with the National Code requirements; new designs of reflectors have added efficiency and more pleasing effects to various types of illumination. Many similar improvements have been made in shop practice and in shop lighting.

The Association has shown good results during the year and its prestige and influence are steadily increasing its recommendations are being generally adopted. One example of interest is the change made by several large railway systems from one-hundred and ten volts down to sixty volts for "head end" service as recommended by the Association.

Detailed specifications have been prepared covering car lighting belts, incandescent lamps, wire, ball bearings for car dynamos and also for other material. These should be of considerable service to the car lighting engineer.

The report of the Secretary-Treasurer shows a gain in membership and good financial condition due in considerable measure to the able and loyal efforts of Secretary Andreucetti.

We have before us for discussion a large amount of interesting data and recommendations for discussion and I trust that each member will miss no session if he can avoid it, as each subject is interesting and deserving of careful study.

At this time, I desire to thank the members of the Executive Committee, the Chairmen and members of Standing Committees and other members who have labored so faithfully to conduct the work of the Association and prepare the able reports which are to be presented.

The report of the Secretary Treasurer was then read and accepted. The Secretary read letters from Mr. Fuller, Assistant General Manager of the Union Pacific Railroad: Mr. Keegan, of the Grand Rapids and Indiana Railroad: Mr. Seely of the Rock Island Railroad: and Mr. Hobbs, General Superintendent of the Louisiana Western Railroad, honorary members of the Association who regretted their inability to attend the Convention.

The report of the committee on Installation of Wiring for Electric Light and Power in Railway Shops as published in the October issue of the *Railway Electrical Engineer* was then read.

Mr. A. J. Collet: (U. P.) said that they have entirely eliminated all drop cord lights and found that the portable lights as connected to a permanent socket on the tool itself offers ample illumination for special work, such as boring cylinders, etc.

Wiring in Railway Machine Shops.

Mr. D. B. Pastorius: (Penn. R. R.) said that he did not consider the wiring of machine shops as advocated in this report to be flexible enough. He said that it very often became necessary to change the position of tools and the size of motors at a certain point. He recommended that overhead mains be run on the outside wall of the shop, these not to be placed in conduit but run as open wires. Instead of using panels for distribution, a connection is taken from these mains, run down the side of the wall in conduit, thence underground to that tool. Each motor is to be placed on a separate circuit.

Mr. J. A. Andreucetti, (C. & N. W.) said that he considered the practice of open wiring in any railroad building should be avoided. He considered the scheme advocated by Mr. Pastorius as undesirable from the maintenance point of view. He recommended that a steel cabinet with sufficient branches to take care of any proposed outlay be installed. In this way a connection could be run to a main switch at the distribution box and the individual motor circuit tapped off at that point.

A. J. Collett (U. Pac.) said that he didn't consider that either the open wiring or the panel board system met the special conditions in railroad machine shops as well as a certain system which they had installed. This consisted of a loop system of the main feeder wires running along the whole shop. This is placed in conduit and numerous straightaway outlet box fittings with fuses were installed for tapping in special machine circuits. Where more then one machine was connected to a line, individual circuit breakers were installed on each machine. He said this was considerably cheaper than panel board construction, and at the same time was fully as flexible as that system recommended by Mr. Pastorious, yet did not have the disadvantages of open wiring.

Fifth Annual Banquet Association Railway Electrical Engineers in the Gold Room of the Congress Hotel, Thursday, October 24th, 1912.*

Round House Wiring and Lighting.

Mr. C. R. Gilman, (C. M. & St. P.) said they very recently had some trouble in a round house with grounds in the vertical pipes coming down to the outlets for attachment plugs. This seemed to be caused by the condensation on the inside of the conduit which dripped into the box so that it became necessary to install a drain from the box.

Mr. D. J. Cartwright (Lehigh Valley) said they had found similar trouble, but had attributed it to the fact that the conduit was mounted on a concrete or an iron post which would make the temperature of the iron conduit be somewhat lower than the surrounding air. In one particular instance it became necessary to place blocks of wood an inch thick between the conduit and concrete in order to eliminate this condensation. In another installation in which he buried the conduit in the concrete he said it remained entirely dry so that 3½ years afterward when he had occasion to remove the wiring found the soap stone and dust in the conduit perfectly dry.

Mr. A. J. Farrelly (C. & N. W.) then stated that the new freight round house at Butler had just been completed and was wired in accordance with the recommendations of this committee report. He stated that five different kinds of lighting had been installed in various sections of the round house as follows:—

One section with three bulls-eye headlights, two at the head of the stall, and one at the foot. Another section with two headlights one at either end of the stall. Another section was lighted by two tungsten clusters. Another was a combination of a headlight at the further end of the stall and a single tungsten unit at the foot of the stall, and the other was a single tungsten unit at either end of the stall. After a comparison of the various systems by all classes of men interested, it was decided to adopt the system using three headlights. He said that the main advantages of this headlight system seemed to be that it directed the light to the point where it was most needed; it was entirely removed from the smoke zone of the round house, being placed on the wall about 8ft. from the floor, and as the entire unit was encased in a dust proof casing, the only cleaning necessary was to dipe off the outside of the bulls-eye lens. He said this system did not seem to deteriorate in service to any appreciable extent, while the overhead system readily became covered with soot, and the lighting efficiency was seriously impaired. Mr. Farrelly was then asked if these headlights did not throw the entire flux of light down between the engines leaving the aisles entirely dark. He said that it was surprising the amount of light which was delivered to this runway. There

*Large size photograph of this banquet can be obtained from J. W. Taylor, Photographer, 440 S. Dearborn St., Chicago Price $1.50.

seemed to be plenty of light both here and on the benches placed against the wall immediately below the lights without any additional drop cords.

Upon motion the meeting adjourned.

TUESDAY AFTERNOON SESSION.

Mr. E. W. Jansen read the report of the Committee on Data and Information as published in the October issue of the *Railway Electrical Engineer*.

Car Lighting Belts.

Supplementing that part of the report pertaining to belt life. Mr. Jansen stated that the average age of these equipments is about 1 year 9 months. They have a long link suspension on each axle and armature pulley, 21 in. and 11 in. respectively, and accordingly a belt is not run very tight.

Mr. Colgrove (Illinois Central) stated that he considered one of the main reasons for long belt line operated on this road was that the belts are carried under the brake beam instead of over it. Many cases where the belts are passed over the brake beam, the clearance is so small that when the brakes are set the brake beam raises enough to rub against the belt and tear the belt apart.

Mr. E. W. Jansen (Illinois Central) called attention to the side brace for suspensions and said that he considered that as a very valuable safety device.

President Frost then asked for some information relative to the new spring drive designed by J. D. Younger of the I. C. R. R., and placed in service to some extent on that road.

Mr. J. D. Younger (Illinois Central) said that the first grooved pulley made by them consisted of a 10 in. armature and 21 in. axle pulley with six grooves ⅞ in. deep in each. The first springs employed were made of No. 12 piano wire and wound to a ⅜ in. spiral spring. On the first trip of 100 miles two belts were lost, so they came to the conclusion that they were possibly too close together and that in striking a low space in the track, taking a switch, etc., where there was considerable jar to the trucks this might cause the springs to became entangled with each other. He later had two ½ in. springs wound and applied them to the two outside grooves. The car made several trips satisfactorily, but after a while the spring drive became somewhat stretched out and ran loose, so that they would occasionally climb from one groove to another. They are now having other pulleys made with grooves 2 in. deep, but these are not ready for application at the present time.

Mr. Younger pointed out that with this type of a drive no take up springs would be necessary. Machine can be mounted practically rigid, and accordingly the wear on bearings and pulleys considerably reduced. He said that the two ½ in. spring belts were applied to a 50 ampere machine and operated satisfactorily.

Mr. E. W. Jansen (Illinois Central) was asked what he considered the most economical belt to use for car lighting work, a high priced belt, a medium priced belt or a low priced belt. He stated that he felt that the best of everything is none too good when it comes to car lighting. There is less chance of a failure with a good belt than with a poor one. They use the best belt they can buy and have very little belt trouble. He also stated that they installed a leather belt on trial which up to the present time had made over 120,000 miles.

Mr. Hutchison (Rock Island R. R.) stated that he had been conducting some tests for the past three years, a partial report of which was included in last years report of the Committee on Data and Information. These tests have shown that 75% of the belts that are used in railway car lighting service are lost and only 25% of them actually worn out. This indicates that it was unnecessary to employ high priced belts, for the good qualities of a belt which would give it long life are seldom actually given a chance to make good. He states that these tests would be complete in about four months at which time the results would be given the Association through the medium of the *Railway Electrical Engineer*.

Mr. G. B. Colgrove (Illinois Central) stated that it was his experience that five ply belts broke at the clamp quicker than the four ply, and that they found the cheaper grade of belt broke and tore out at the clamps.

Round House Wiring.

Mr. G. B. Colegrove (Illinois Central) stated that it bers had used lead covered cable for round houses. Mr. J. R. Sloan (P. R. R.) said that they had made several installations of that type recently but could not make any definite report at the present time.

E. W. Jansen (Illniois Central) said that they had equipped many round houses with a three wire lighting system using open feeders mounted outside the round house just under the eaves. They placed a galvanized fuse box outside of each stall and run through the wall a condulet switch inside. They provide three tungsten lamps installed with enameled steel reflectors in each stall. The wiring from the switch box to the lights is run in conduit along the girder.

Mr. Andreucetti (C. & N. W.) contended that open wiring on buildings was prohibited by the National Underwriters Code, but Mr. Jansen said that they usually did better work than was required by the Underwriters, using higher grade wire, etc., but that in certain cases open wiring in buildings was preferred. It seemed to be the consensus of opinion that special wiring for all portable or localized lights in machine shops should be eliminated.

Ball Bearings.

Mr. Sloan (P. R. R.) then read the report of the Sub-Committee on Ball Bearings as published in the October issue of the *Railway Electrical Engineer*.

Mr. F. H. Poor (S. K. F. Ball Bearing Co.) said that although ball bearings were comparatively new in Car Lighting, they have long been on the market in service equally if not more sever than that of the axle generators. Ball bearings are now made with extreme accuracy in fact variation of 4 to 6—10,000 of an in. are now guaranteed. He said that ball bearing manufacturers had much experience in railway and automobile work on machines of extremely heavy duty and under all kinds of speed conditions. He said that many ball bearings have been in service on axle generators for more than a year without any replacement whatsoever.

Mr. J. R. Sloan (P. R. R.) pointed out the importance of standardizing ball bearings before a larger number of various types and sizes had been purchased by railroads. It will become necessary to carry only a stock for one or two different types of bearings. He said that all the ball bearing manufacturers can furnish the 412 size bearing as recommended by the Committee, which will have standard outside dimensions.

President Frost then asked what would likely happen if a ball broke. Mr. J. R. Sloan said there had been one such case of trouble on the Pennsylvania recently which required re-winding of the armature and new fields. To offset this, however, he pointed out the fact that similar trouble from worn bearings and hot boxes where the plain types bearings are used are not at all unusual. Mr. Sloan said that in June 1911 they equipped a number of

these generators with the 412 size bearings and are all in service yet.

Mr. E. S. McNab (C. P. R.) said that they have been operating generators of the Stone system with ball bearings for the past four years. They now have 120 equipped and between 30 and 60 of them have been running over three years. He said that they have had only two cases of failure due to bearing trouble in all that time. Some of the machines have run for several months without lubrication. He said that the bearings they use are mounted on a sleeve which is held on the shaft by means of two locks and nuts.

was, however, largely an accomodation on the shaft. Where it is possible to securely lock the ball race on the shaft, it is to be prefered to the other arrangement. Here you have the ball bearing fitting true on the axle itself while if a sleeve is used there are two fits to make and a liability of error much greater.

Mr. Sloan pointed out that while it is possible to make the bearing at the pulley end a press fit on the armature shaft, it is practically impossible to do so on both ends. This would require the internal diameter of the armature spider be large enough to slip over the inner ball race pressed on the shaft and as this would be too large for

Tour of Inspection of Burnside Shops, One of the Features of the Convention.*
(Note that boiler is jacked up so that stay-bolts on all sides may be rivited without turning boiler.)

Mr. J. D. Younger (I. C.) said that he considered it rather unwise to attempt to standardize ball bearings when we have had practically no experience with them. He suggested that it would be better to try out various sizes and to determine which one would give the best results.

In reply Mr. Sloan (P. R. R.) said that when the size of bearing came up for consideration by the Committee, one member thought the 409 reasonably large enough while another considered 410 more desirable. The ball bearing manufacturers recommended 411. On the advice of one of the railroad companies that had been operating many of the 412 size for over a year and had had no failure with them, the Committee finally agreed on the 412 size.

Mr. Hutchison asked if the bearing could not be simply slipped on the shaft in a close fit and keyed in position instead of being pressed on with a press fit as recommended.

Mr. F. H. Poor said in reply, no ball bearing should have a key-way cut into it. These bearings are made with extreme accuracy and the offset in eccentricity of the key-way bore would damage the bearing seriously in short time, and as to the matter of mounting the ball bearing directly on the shaft or on a sleeve he said that some people might feel that the sleeve was more readily taken off. In any case ball bearings must be securely locked on the sleeve or on the shaft. Ball Bearings are made of such very hard material that when subjected to sudden shocks or severe loads that quite frequently tend to peen on the shaft or sleeve on which they are mounted. If mounted on a sleeve, the armature shaft is in no way injured but if mounted directly on the shaft the replacement is not so easily made. He said that it

8x10 photograph of this group, 75c. Railway Electrical Engineer Chicago

good generator design it becomes necessary to mount the bearing at the commutator end on the sleeve. Mr. Sloan pointed out that in making this report, the Committee is not actually recommending ball bearings for use in car lighting, it merely recommends that where bearings are used they shall conform to the report of the Committee.

Mr. K. Langnickel of the Norma Company, suggested that roller bearings be included in this report. Mr. Sloan stated that the Committee was originally appointed to report on ball bearings; they did not object to roller bearings, but they had simply followed the original instructions. If roller bearings can be made of the same capacity and dimensions as ball bearings recommended he said, this recommendation would apply to roller bearings as well as ball bearings.

Mr. W. L. Batt (Hess-Bright Mfg. Co.) said that most of the roller bearings are made in what are called "annular" sizes and moved an amendment that the report read "ball bearings or roller bearings in annular sizes." This amendment was carried and the report referred to letter ballot and amended.

WEDNESDAY MORNING SESSION.

The report of the Committee on Improvements was read by Mr. H. C. Meloy and at the conclusion, Mr. Meloy stated that most of the Improvements therein referred to, were shown in the Exhibit Hall. Mr. Meloy briefly outlined the work of the Committee stating that a complete canvass of over 250 different manufacturers had been made with circular letters, in some cases four different letters, and personal or telephone calls were made by various members of the Committee. Mr. L. S. Billau asked if there were any ampere hour meters now in service in connection with axle generators. He

requested some views from the various members on using ampere hour meters for the control of the battery and discharge.

Mr. Edward Wray, of the *Railway Electrical Engineer,* said that the resistor type meter as mentioned in this report is of very recent developement, in fact the first consignment of 200 to the P. R. R., has just gone into service. He said however, that with this new type meter it becomes possible to control the charge which the storage battery of an axle equipment receives, on the ampere hour basis. He said that ampere hour principle of control was considered by many battery experts as being fully as reliable as the specific gravity indication itself.

Mr. Edward Wray stated that he had been requested by the Consolidated Company to announce that their generators can be equipped with ball bearings as well as plain bearings just as other generators mentioned in this report are.

Train Lighting Practice.

The report of the committee on Train Lighting Practice as published in the October number of the *Railway Electrical Engineer* was then read by Mr. F. E. Hutchison, Chairman. Mr. C. R. Gilman (C. M. & St. P.) stated that they had worked out a battery charge system for their head end trains in which the battery is charged independent of the lamp circuit. Connections are made in the dynamo car of all three of the train lines and the rear loop at the end of the train pulled out. All the batteries in the train are on one circuit and the lamps on another with a common conductor. A hand resistance is placed in the lamp circuit which makes it possible to maintain constant lamp voltage while the generator voltage may rise to any desired value in charging batteries. As to the drop in lamp voltage at the rear of the train due to the fact that lamps are then operating on a two wire circuit, Mr. Gilman said that this was found to be not more than 3% on a 10 car train. The electrician can read separately the lamp and battery current and battery voltage so that he has a pretty good idea what the batteries are doing.

Mr. John M. Craig (P. R. R.) raised a question in regard to the statement made by the committee that two men can take care of 15 cars per day exclusive of batteries and shop work. Mr. Hutchinson, Chairman, of the Committee explained that it is the result of long experience on their road that two men can look after the inspection of regulators and dynamos of 15 cars per day of 10 hours.

Mr. Frost (Santa Fe) said that the number of cars assigned per man will depend entirely on the work performed at that station. If the cars are on local runs of a short distance in which the car is in the yard every day and comparatively few men will handle a larger number of cars. He stated that at the Los Angeles terminal they had a large amount of local ocean service. 60 departures per day were here taken care of by 6 men, whereas, at the Chicago terminal where there is no local service it requires 13 men to handle 33 departures per day. He pointed out that in Chicago however, they take care of all battery washing, overhauling machines, transferring the equipments from one car to another, etc., so it is evident that it is hardly fair to make any statement as to the number of cars inspected per man at any terminal unless the general conditions are known. He stated that the average, including inspection both enroute and at terminals, shop repairs, battery and generator repairs, etc., is about 13 cars to each man on the entire system. Mr. D. J. Cartwright (L. V.) stated that he had investigated these conditions on a number of various railroads and found an average of approximately 10 cars per man.

Mr. E. M. Cutting (So. Pac.) asked for some information relative to arrangements for handling Pullman cars. He said that on some of their cars the Pullman Company did all the work and billed the railroad company on a basis of $3.00 per thousand car miles.

Mr. L. S. Billau (B. & O.) said that where they operated Pullman cars they were equipped straight storage or head end system, the Pullman Company maintained all their own axle lighted cars. At certain points where the number of cars do not justify the Pullman Co., placing any man there, the company does the work and bills them for it. They also have an understanding that if any trouble is found by any railroad inspector he will make emergency repairs and the Pullman Company receives bill to cover. As to failure Mr. Billau said that they did not have any system of penalty, but he thought that this was a desirable policy as it would undoubtedly improve service.

Brake Beam Troubles.

Mr. C. R. Gilman (C. M. & St. P.) called attention to the editorial on "Brake Beam Troubles" published in the October issue of the *Railway Electrical Engineer* and said that he considered that the recomendation made in that editorial was very desirable and one which should receive the consideration of the Association at this time. This recommendation was to the effect that the brake beams be transferred so as to bear on the opposite side of the car wheel, thus eliminating the trouble from the belt rubbing against the brake beam; it would also make it possible to obtain proper generator clearance.

Mr. L. S. Billau, (B. & O.) pointed out that the axle generator is one of the latest devices added to a passenger car. Both truck and car body had been practically

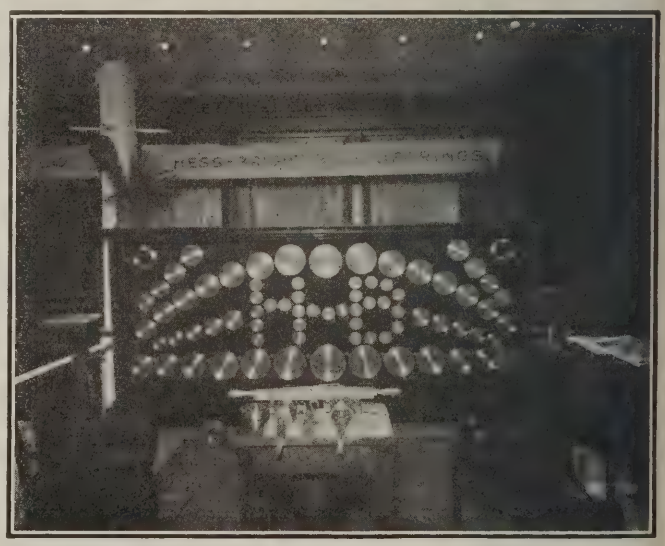


Exhibit of the Hess-Bright Ball Bearing Co.

developed to their present state before axle generators were installed, so it has rather been a case of the axle generator accommodating itself to the truck rather than the truck being accommodated to meet the requirements of the axle generator. He said that one subject given the M. C. B. Train Lighting Committee for investigation is the standard design of axle dynamo suspension. He said that the committee is going into the matter in a very broad way and will treat all phases of it. He said that he thought it would be very proper for our Committee on Standards to get information together and make recommendations which would be available to the M. C. B. Committee.

Mr. E. S. Nab (C. P. R.) stated that the Canadian

Pacific have adopted a standard 6 wheel truck on which there is no end sill on either end of truck. The brake beam is placed on the inside of the wheels at the end on which the generator is suspended.

Mr. D. J. Cartwright (L. V.) said that he did not agree with the recommendation of the committee in regard to placing the generator on the forward truck of a car on through trains which always ran in the same direction. He said that in the winter time there would be a tendency for the snow to collect on the generator and make the best slip.

Battery Boxes.

Mr. Cartwright stated that they were applying steel battery boxes on all wooden equipment. They are placing a 1" hard pine floor in the bottom of the box and painting the inside with ordinary engine black. These cars have been in service for approximately a year and no trouble has developed yet. He stated that with Edison batteries the 5 cell trays were desirable as these

Exhibit of the Safety Car Heating & Lighting Co.

made a convenient unit, 25 cells of Edison batteries replacing 16 cells of lead.

Mr. Gilman asked Mr. Cartwright what the idea was in using steel batteries on wooden cars; wooden battery boxes are considered cheaper and far superior in the matter of grounds, etc.

Mr. Cartwright said that the main idea in using the steel box was to protect the body of the car from fire in case of short circuit or other arcing troubles.

Mr. Gilman pointed out that where the recommendation of the Committee on Standards were followed in placing all wire in conduit, the trouble from fire was very remote.

The Nickel Iron Cell.

As to methods of determining the condition of charge of a nickel iron cell, Mr. D. J. Cartwright stated that this might be done in three ways. First, note the voltage after all lights have been on for 5 or 10 minutes; Second, by means of a goose neck arrangement which makes it possible to count the bubbles emitted from any certain cell from which knowing the discharge rate, the per cent of capacity remains in the battery may be made by referring to a chart; third, by the means of the ampere hour meter.

Mr. H. G. Thompson of the Edison Storage Battery Company stated that the only accurate way of measuring charge is the ampere hour method, but that the voltage indication might be safely used to a fair degree of accuracy.

The voltage of any battery depends on its discharge rate. He said that a 4 or 5 minute discharge would be sufficient to dispose of any peak voltage which might exist and the voltage indication would then give a fair idea of the condition of the battery. He said that this method was used quite extensively with electrical vehicle works.

Battery Trays.

The committee recommend that the trays be put to-

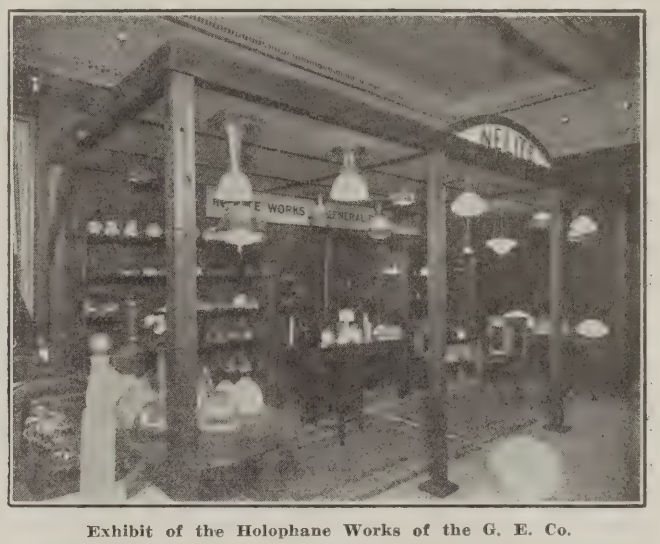


Exhibit of the Holophane Works of the G. E. Co.

gether with white lead at the joints, that oak be avoided as material for constructing trays.

President Frost said he considered oak one of the poorest woods for this purpose as it absorbs acid very readily and unless some special preservative of unusual quality is used, the wood will go to pieces in a short time.

Mr. H. G. Thompson stated that hard maple will take an impregnation of acid resisting paint better than oak. He said that pine would not however, because it is too sappy. He said that experiments have shown that paint could be made to enter farther into hard maple than into oak.

Mr. Gilman stated that there seemed to be an organic acid contained in the oak which attacked the lead lining of the tank.

Mr. J. R. Sloan (P. R. R.) stated that they had submitted this question to the chief forester and chief chemist of the P. R. R. recently and obtained the advice that there are two varieties of oak which were suitable for this service but it takes an expert lumberman to determine whether we are getting one of these two kinds or one of the many other varieties of oak. He stated that the recommendation was that either of these two kinds of oak was the most serviceable wood for this purpose.

President Frost stated that it was their practice to use yellow pine for battery trays. The wood is thoroughly dryed then dipped into very hot parafin which soaks deeply into the wood; this is then dipped into a much cooler bath of parafin and beeswax. This makes quite a thick coating and he stated that they have had battery trays remain in service for 5 years and still be in fairly good condiion. Where the parafin and beeswax are employed no painting is required. He stated they had used hard rubber jars exclusively and have found it good practice to have the tops of the jars to project about ¾" above the tops of the wooden trays. This seems to prevent seepage of acid over the top which is the cause of trays going to pieces so rapidly at this point.

WEDNESDAY AFTERNOON SESSION.

Shop Practice.

Mr. George W. Cravens read the report of the Committee on Shop Practice as published in the October issue of the *Railway Electrical Engineer*. In discussing the report Mr. L. S. Billau (B. & O.) stated that they had found it cheaper and to give more reliable operation where the current is purchased from a central station. This seemed to be the general opinion of most of the men present. An interesting discussion of the subject of electric welding seemed to indicate that while the oxyacteylene system might have advantages in cutting metal the electric arc process was undoubtedly superior for patching and other repairs.

Mr. Ashley E. Peck then read his interesting paper on the application of steam turbines for railway shop work which is given herewith.

Small Steam Turbines in Railway Shop Work

By W. J. A. London and Ashley P. Peck.

Practically all the numerous and exhaustive papers that have been published on the subject of Steam Turbines have dealt with the larger units, and the authors wish at the outset to emphasize the fact that there is a marked difference between the field and requirements of the larger machines than those comprising the smaller units.

A few interesting papers have been written, devoted entirely to small turbines, but the limitations of this type of machine with regard to its *commercial* efficiency, as distinguished from its *steam* efficiency is a subject on which there has been very little discussion, and in writing this paper the authors had in mind that the opinion of engineers actually buying or operating such machinery would prove at this time of exceptional value, not only to the builder of such machines, but to the purchaser as well.

In large steam turbine work, the question of efficiency is of paramount importance and this factor is the basis of all designs. The machine is developed to obtain this maximum efficiency under the given conditions, and no reasonable expense is spared to attain this end. In other words, the designer, while naturally building his machine as cheap as possible, must not consider expense in construction if any cheaper design would affect the efficiency to the smallest degree.

The designers of small steam turbines are confronted with an entirely different proposition. In order to fulfill the requirements of the market, these machines must be made in quantities. Furthermore, they must be made, on the one hand, to sell as cheaply as possible, and on the other hand, to meet certain efficiency guarantees. In some cases a machine will be sold on its water rate efficiency. In other cases steam efficiency is of no consequence, and in a case like this, the machine is obviously sold on design or price, but however, we must understand that a *standard* frame must fill both the requirements.

The duties which the small steam turbines are now called upon to perform, demand at the outset *absolute reliability*, so that the question of efficiency must not be considered at the expense of reliability and cost.

It is a mistake to assume that the average thermal efficiency of, say, 40% to 45%, which is now obtained with small turbines operating with standard conditions, is the maximum possible for this type of machine. There is no reason at all why small machines cannot be built to approach the thermal efficiency obtained on larger machines of 65% to 70%, but up to the present time this efficiency has not been demanded, nor (and *this* is more important) *has the customer been willing to pay for it*: and furthermore, we think we will be able to show that there is no necessity for such an efficiency. The theory of the steam turbine is no longer the mystery it was ten or even five years ago, it being well-known that the various makes of small steam turbines are of the impulse type, as this lends itself better to compact design —which is the prime feature of all small turbines. In the impulse type (so-called) the steam is expanded in a nozzle or jet end the Kinetic Energy of this jet is absorbed by passing one or more times through the buckets of the turbine rotor. The efficiency obtainable by a certain design is no longer guess work and the two factors governing this efficiency are well known to be, first, peripheral speed, and secondly, number of stages or passes of the steam through the buckets of the rotor.

Small impulse steam turbines may be classed under two general types, single stage and multi-stage. In the single stage type, the steam may pass from the jets once through the buckets and thence out, or in the multi-velocity single stage type, the steam may reverse and re-enter the rotor two or more times, its velocity energy being extracted successively with each reversal.

In the multi-stage turbine, the steam is expanded successively through two or more single or multi-velocity stages, imparting to each stage a portion of its energy during expansion.

It has been demonstrated that with turbines of the single stage type, employing the multi-velocity stage principle, the maximum thermal efficiency is obtainable with only two reversals; in other words, the wheel rim velocity must be substantially one-quarter of the steam velocity. It has also been demonstrated by Professor Stumpf and others that an efficiency of 60% to 65%, can be obtained on a single wheel. A single stage machine running non-condensing, with a wheel 2' in diameter running at 2500 R. P. M. employing about three or four reversals will give an efficiency of 40%. The same turbine to give, say, 60% efficiency would have a wheel 4.5 ft. in diameter. Experience has shown that the cost of small turbines follows very closely the square of the diameter. In other words, a 100 H. P. machine designed for 40% efficiency, would sell for approximately one-fifth of the cost of a turbine of the same H. P. developing 60% thermal efficiency.

Another thing to consider is the fact that in the highly efficient turbine, the wheel stresses alone would be 5 times those in the commercial type of machine.

Again, considering the case of a multi-stage machine. Here we have the number of stages varying inversely as the square of the velocity per stage. In other words, a turbine operating under duplicate conditions to those mentioned, and having a thermal efficiency of 40% would have about five stages. To obtain the 60%, it would require 25 stages, giving a difference in cost practically equal to that mentioned above for the single-stage machine.

The above shows that whichever way we take it and whatever type of a machine is used, efficiency can only be obtained at the expense of first cost. In large turbines it can be easily shown why a customer should decide on a higher priced machine with a better water

rate; for instance, with a 5000 K. W. machine and a steam consumption of 16 pounds per K. W. if that consumption were only 15 lbs. per K. W. and assuming a 10% investment on his money, he could afford to pay $36,000 extra.

That this argument does not hold good with the smaller units is easily demonstrated. Take, for instance, a 50 K. W. generator set, the water rate of this machine being, say, 60 lbs. per K. W. One lb. saving in steam consumption on this unit should raise the price approximately 15%.

The above points are brought out with the object of showing that while efficiency in small turbine units is

Visit to Burnside Shops. A stop in the Power Plant with Turbines in the Foreground. *

often discussed by the purchaser as being of vital importance, when it comes to buying the machine he is not consistent. Of course, if the price is the same and the water rate is better in one than in the other, he will naturally favor the more efficient machine, but does he bear in mind that higher efficiency can only be obtained at the expense of reliability? In single stage machines, the larger the wheel the greater the duties on the bearings, also the increased liability of distortion. In the multi-stage machine, the more stages we have, the more internal glands we have.

Considering first the application of small steam turbines for driving auxiliaries in large power plants, such as exciters, boiler-feed, circulating and hot well pumps, it is now acknowledged standard practice in up-to-date power houses to run the auxiliaries by steam and to run these machines non-condensing, exhausting into feed water heaters. A heat balance will show that in the average power house, the exhaust from the auxiliaries can all be taken care of in the feed water heater, so that the steam economy proper in the smaller unit itself is of no great importance. The steam turbine is therefore being adopted more and more for auxiliary drive only because of its many obvious advantages. The increased use of superheated steam and the troubles that are experienced with same in small reciprocating engines is one of the main reasons for the rapid progress made by turbine driven auxiliaries. Again, the growing tendency to reduce station costs by the employment of cheap labor, necessitates apparatus that is simple and "fool proof." The turbine resembles the electric motor in its simplicity,—the lubrication and attendance being about the same, whereas the marked advantage of having the source of power taken direct from the boiler instead of through any intermediate source naturally has many advantages over the electric motor, especially when same is placed in the basement where electrical leaks ar liable to cause serious injury.

As an approved form of prime-mover for generators for power and light in shops, factories, etc., and for head-end lighting, the turbine now occupies an important position. It is compact, requiring small floor space, simple in construction—requiring but little attention and practically no adjustments during long periods of operation and has an almost negligable maintenance cost. The lubrication is entirely automatic, being of the ring-oiling or forced feed type.

A marked advantage of the steam turbine from the reciprocating engine, where the exhaust steam from same is required for manufacturing purposes, lies in the fact, that the steam turbine delivers to the Exhaust System, absolutely clean steam, without any cylinder oil contained therein, as in the case of the reciprocating engine and without the necessity and uncertainties of so-called oil extractors in the exhaust lines.

Another feature in favor of the steam turbine, is the remarkable maintained efficiency of the turbine, as compared with reciprocating engines. The steam turbine will hold its original efficiency for long periods, as there is no appreciable wear on the buckets or jets, therefore, no change in shape, while the reciprocating engine depends for obtaining its guaranteed water rate, upon a minimum fiction loss and absolutely steam tight valves.

That up to date station engineers appreciate that reliability of their auxiliary apparatus is of infinitely more importance than the individual unit efficiency, cannot be better demonstrated than by citing several up-to-date stations where steam turbines are used for driving such apparatus as circulating pumps, the speed of which is away below that of even reasonably efficient conditions.

Several modern stations are now equipped with small turbines operating at no higher speed than 1000 R. P. M. and in one instance a turbine is installed for pump work at as low a speed as 550 R. P. M. This last machine has a water rate of 65.6 lbs. as against 26.7 lbs. (per B. H. P.) that would be expected from a reciprocating engine. There is obviously only one reason why turbines were installed in these stations, and that is, their absolute reliability.

We are all inclined, in looking through a power house, to consider the apparatus in the following order of their importance; the main generators, the boilers, and lastly, the boiler feed pumps. We never give the matter a thought that if the boiler feed pumps go out of com-

*8x10 photo of this group 75c. Railway Electrical Engineer, Chicago.

mission, the whole plant would be shut down. Again, take the question of condenser pumps. If these go out of order, on a 5000 K. W. machine and the machine switches over to atmosphere, the coal consumption is increased about 3½ tons per hour.

In street railway work the duty often called upon by both the main units and the whole plant is probably the most severe of any power equipment. Particularly in the electrification of tunnels we find installations where the load will vary from zero to 3000 K. W. at one jump. Imagine the effect of this on the boilers. Experience has shown that the dangers due to water hammer can be practically ignored in turbine machinery. The governing of both large and small steam turbines has been so perfected during the last few years, that it is an undisputed fact that the turbine is much better suited for sudden changes of load than any other equivalent piece of apparatus.

The abuse that small turbines will stand is often enough to surprise even the designer. We remember an instance in one of the largest power houses in the country of seeing a hot well turbine pump in a small pit below the base of the floor. This pit was flooded absolutely up to the top, turbine and pump being entirely immersed. The machine was running along as if nothing had happened and our attention was drawn to the fact that there was a machine underneath the level of the water only by the surging action of the water on the surface.

It is still believed by many engineers that the water rates actually obtained on small turbines are much higher than those obtained on reciprocating engines of equal power, and it has occurred to us that the above arguments depreciating the importance of efficiency might be taken as an acknowledgment of this fact. It is certainly true that in some cases a small reciprocating engine can beat the turbine, but in the majority of cases it must be morne in mind that reciprocating engine guarantees are generally given in pounds of steam per *indicated* horse power. This at best is indefinite, and we all know that the depreciation and consequent impairment of efficiency in a reciprocating engine is very much more rapid than is the case with steam turbines.

As compared with reciprocating steam engines, operating non-condensing or condensing, the greater economy in steam in the engine, is usually unquestioned, but it is obtained with a greater investment, more attention, more floor space, higher maintenance cost and less reliability in a reciprocating engine than in a turbine.

Take for instance, a railway shop, where exhaust steam is required the year around for drying purposes and during the winter months for heating, the very economy of the reciprocating engine makes the necessity for the use of live steam from boilers at times or continuously to meet the demands for heating or drying. Maximum efficiency does not always mean low water rate in the prime mover, but is an over-all item.

It may be interesting at this time to analyze a comparison between non-condensing reciprocating engine driven and turbine driven generators, rated at 100 K. W. normal true energy suitable for a railway shop power equipment. Assume in each case, a pressure at throttle of 125 lbs. and an average back pressure at engine or turbine exhaust of 3 lbs., sixty cycle alternating current is used. The engine would be of the simple single or four-valve type operating at 277 or 200 R. P. M., respectively, and the turbine at 3600 R. P. M.

The water rate of a brand-new simple single valve engine could be taken at full load as 28 lbs., and of the four-valve at 24 lbs., per *indicated* H. P. Correcting this for the 9 lbs. back pressure and assuming a mechanical efficiency of 91% in each case gives us a water rate per *Brake* H. P. of 32.4 lbs. and 28 lbs. respectively. Assuming a full-load generator efficiency over-all including friction and windage of an operating P. F. of 80%, of 93% and 91.6% respectively, we have an approximate water rate per K. W. hour for the single valve, of 46.6 lbs. and for the four-valve of 41 lbs.

The turbine water rate per B. H. P. is 31.75 lbs. at free atmospheric exhaust and with 3 lbs. back pressure this goes to 34.2 lbs.

A 125 K. V. A. two-pole 3600 R. P. M. A. C. turbo-alternator of good design will test to 88% efficiency at full load and 80% power factor. This gives a water rate per K. W. hour for the unit of 52.2 lbs.

In this typical comparison, it is noted that the single valve reciprocating engine, operating under similar conditions to a steam turbine, will develop an over-all water rate efficiency 5.6 lbs. per K. W. hour at full-load better than the turbine, and the four-valve water rate will exceed that of a turbine approximately 11.2 lbs. per K. W. hour at full-load.

This saving is an important consideration were there to be no uses for the exhaust steam, which is not the case in railway shop practice, as the exhaust from the prime movers, but rarely goes to atmosphere.

In boiler feed pump work it is very difficult to obtain any information bearing on the actual water rates obtained with reciprocating pumps. The best information at our disposal is the series of tests that were carefully carried out on board the U. S. Scout Cruisers Birmingham, Chester and Salem, which are tabulated below, and in the same table is shown the figures obtainable from turbine pumps, which shows an advantage in favor of the turbine pump of about 31.2%.

Water Rates of Small Turbines

Birmingham	183	6	329	488	83.0	61.8	25.5
Salem	203	6	193	690	91.8	61.2	33.6
Chester	187	6.7	219	610	101.0	64.0	34.6
					275.8	187.0	93.7
Average					91.9	62.4	31.2

With reference to the general subject of steam consumption, and the absurd statements that are sometimes made that a small turbine is passing, say, twice as much steam as it ought to, it may be interesting to review the principal governing steam consumption in small turbines with special application to Napier's simple formula.

$$W = \frac{P\ A}{70}$$

where

W=Weight of steam per second;
P=Absolute steam pressure;
A=Area of orifice in square inches;

for the flow of steam through nozzles cannot be used to greater commercial advantage than it is at the present time. This well-known formula has been proven so many times to be approximately correct that it is a pity that it is not more extensively used to compute the steam consumption. The majority of small turbines now operate with a terminal pressure at the jet about 0.58 of the initial pressure, so that this formula can be readily applied to any machine and the steam consumption determined by a gauge in the steam ring.

The maker could be called upon to give the number and size of the jets, and in this way an instantaneous reading could be taken showing the amount of steam passing at any one time. If this were done, less claims would be made that a turbine is passing a greater amount of steam than the makers claim for it.

By a slight modification of the constant 70 in Napier's formula for various jets, figures can be obtained as accurate as is possible by actual measurement. In a series of tests carried out on a certain machine in seven readings with a ring pressure carrying from 40 to 150 pounds, the minimum discrepancy between the calculated and the actual results was 1.3 per cent. and the mean over all the readings, 0.443 per cent.

The actual figures obtainable on test and those calculated are as follows:

Napier's Formula	Actual Tests	Per Cent. Variation
2,028	2,043.6	0.8
1,264	1,248.0	1.3
1,935	1,934.0	0.0
2,625	2,638.0	0.4
1,905	1,906.0	0.0
3,047	3,066.0	0.6
2,272	2,272.0	0.0
		3.1

Average 0.443

In view of the fact that this paper is prepared with special reference to railway shop work, the subject of condensing steam turbines has been touched on but lightly, as we understand that almost universally power equipments for railway shops are operating non-condensing in view of the many uses for the exhaust steam.

The steam turbine like the air brake, the steel railway coach, the locomotive super-heater and other improvements of recent years in railroad practice, has succeeded in breaking down the traditional conservatism which marks "something new" in all mechanical undertakings and this fact is not surprising when it is recalled that the first type of steam engine dating back to a century before the Christian Era ,was nothing more or less than a steam turbine. The rapid introduction and commercial success of the large power turbine units in common use today, rendered the introduction of the small turbine, but natural in every way, and as a substitute for a reciprocating engine it has an assured and prominent position.

Discussion of Paper on Steam Turbines.

In discussing this paper Mr. Willard Doud (I. C.) stated that before installing exhaust steam turbines at their Burnside Shops, 11 boilers had been worked to full capacity. With two exhaust steam turbines, however, they have been able to operate the shop with 8 boilers each with an increasing demand for power. He stated that in one new roundhouse they have installed a hot water system in which a centrifugal pump is employed for circulating the water. The latent heat of steam is utilized by the hot water system. In this way it is possible to operate the exhaust steam turbine at a comparatively low vacuum even in rather cold weather.

On being asked for further information regarding low pressure turbines, Mr. Peck stated that on account of the low pressure employed the turbine must be designed to pass an enormous volume of steam. He said although exhaust steam turbines might be in some cases used to a very great advantage, each problem must be given very careful consideration. He stated however, that he thought the load curve of a railroad shop would be favorable to use of the exhaust steam turbine.

Mr. C. H. Quinn (Norfolk & Western) stated that they have had a 500 k. w. turbine in service for approximately six years. This now gives a water economy at the switch board including all losses of the vacuum pump exciter of 16.8 lbs. per h. p. hr.

Mr. Douglas (General Electric Co.) stated that the problem of the railroad shop installation is a rather peculiar one, as so much steam is required in the winter time for heating purposes. With low pressure turbines it may be possible to obtain a good efficiency in the summer time but this economy during perhaps 6 months of the year must be figured against the entire turbine investment. He stated however, there was a turbine on the market known as the Bleeder type which has an opening so that steam may be taken out after it has passed about half way through the turbine. The amount of steam thus tapped off for heating purposes can be regulated at will, in fact in the winter time the steam may be tapped off at sufficiently high pressure for the heating system and the turbine run noncondensing. He said that this turbine seems to meet the railroad problem fairly well.

On being asked why the exhaust steam turbine operated so much better on low pressure than the reciprocating engine, does, Mr. Douglas stated that at the low pressure of 26 to 28 in. of vacuum, the steam is of such immense volume that it is difficult to build cylinders large enough to handle it economically. He pointed out that steam at 28 in. vacuum is of twice the volume it is at 29 in., and at 26 in., it is twice the volume of 28 in., approximately; in other words a steam engine designed to utilize steam down to 28 in., vacuum must have cylinders of twice the volume of the engine designed for 26 in., vacuum. It is practically impossible to work at such low values with the reciprocating engine whereas the steam turbine meets the situation beautifully. He also pointed out that there is as much energy given out by the steam in expanding from atmosphere down to 20 in., of vacuum as there is from 100 pounds down to atmosphere. He stated that an engine can develop say 50% of the available power between the pressure of 150 pounds and atmosphere but can develop only 25% of the available power from atmosphere to vacuum while a turbine can develop easily 60% of the available power from atmosphere down. The advantage of the exhaust steam turbine are at once evident.

A vote of thanks was extended to Mr. Peck for his excellent paper.

Mr. B. F. Fisher, Jr., of the Westinghouse Lamp Company then read his paper on industrial lighting as follows:

Industrial Plant Lighting.

B. F. Fisher, Jr.

In this day of the efficiency engineer and the system doctor, when railroads are told they are now wasting millions which can be saved, and our conservation commissions tell us that we waste enough in energy and resources to run a tidy little nation, it causes one to wonder what energy or resource we should save at the expense of the others.

It must be borne in mind that energy and resource must be expended to obtain any desired result, and, he who can best expend this energy and obtain the greatest result makes the greater success of his undertakings.

It should be the aim in any industrial plant to have every machine work at its maximum capacity and at its highest efficiency, especially that most complex of all pieces of apparatus—the human mind.

There are few, if any, machines in industrial plants which are not dependent on the action of the human mind for their output, not on account of their development, but to keep them in operation, and in recent years

great strides have been made on many lines to increase the efficiency at which the human mind operates.

Laws have been enacted in many states, and, common practice in others which equals an enactment, require that employees should work in well ventilated, sanitary, clean quarters, that certain conveniences should be provided for the bodily comfort, that a comfortable temperature should be maintained at all times, that the hours of continuous work shall not exceed a certain number, that the air which the employee breathes shall be changed a number times an hour, that the plumbing shall be installed in certain ways.

These laws and customs are good and are based on the theory of increasing the efficiency at which the human mind and human hand operates, but I know of no law nor common practice requiring that employees be provided with proper illumination to enable them to do their work at the greatest efficiency, and I believe there is no element affecting the efficiency of the human mind to a greater extent than the lack of proper illumination.

Many plants are lighted in such a way that the employee cannot see to do his work without straining to the extreme the organs of vision and but few plants are so illuminated that a large part of them are not gloomy, both of which conditions tend to reduce the efficiency of the human mind.

Many plants are said to be well lighted and it is true that they have ample light in them if this light were properly located, directed and protected, but from a study of a great many of these plants it is apparent that the architect or the owner called in a contractor or a wireman and told him to wire the building for lights, leaving the entire question of location, control and equipment to the judgment of the workman.

Owners and architects are just commencing to realize that the arrangement of the lights as to location, mounting heights, reflectors to use, method of utilizing the light and method of control, are subjects worthy of as careful analyses, planning and execution as were the plans for the heating, ventilating, plumbing or any other essential system, or, the arrangement of machinery and the method of handling material.

Few realized until recently that a reasonable amount of careful planning of the lighting system to give the proper illumination would be met by an abundant return in the way of increased quality and increased quantity of production.

All factories, shops and other industrial plants if operated on a reasonably efficient basis, will have to operate at times when natural light will be insufficient for the work to be done and in any large plant a means of artificial illumination will be essential at all times in some departments and in all departments some of the time.

There are many lighting schemes from which the desired illumination can be obtained. By lighting scheme, I mean, source of light. The scheme to be adopted will depend on local conditions, the character of the work to be done, the convenience desired, the construction of the plant and in some cases it may depend on the size of the purse, because up to the present time in almost all plants the necessary illumination has been the last thing considered and on many occasions it has been a case of "cutting the suit to fit the cloth" because the purse would not permit otherwise.

There are three general light sources which can be used in industrial plants, mineral oil with its limited application, gas with a slightly broader application and electricity which the broadest application of any light source known at present, and while it is not intended to infer that mineral oil or gas should be rejected in all cases, because they have their proper application, I will confine myself to electricity as a light source.

Electricity as a light source can be utilized through the medium of comparatively low candle power incandescent lamps which can be made in units from a fraction of a candle power to units of 400 or 500, or even greater candle power. The smaller units requiring voltages somewhat lower than the voltages usually found in industrial plants, but all sizes of lamps are capable of being utilized in these plants.

Then there is the arc lamp which is made in units from approximately 200 candle power to 2000 or 3000 candle power, and last but not least, there is the glow lamps or tube lamps, such as the mercury vapor lamp and the Moore tube, in sizes from approximately 200 candle power to several thousand. Each of these electrical units has its own application and in many cases all of them can be used to advantage in the same large installation and it is necessary in studying the illumination problem for an industrial plant to take into consideration the advantages and disadvantages of each source of light, their merits weighed and a decision arrived at more by the process of illumination than otherwise.

In taking up a problem of industrial plant lighting, the method of procedure which appears logical to the writer is to analyze the plans of the plant. Each illumination project requiring a complete set of plans, whether it be for a new building or an old one. These plans do not have to be elaborate works of art, but they should contain complete information as to floor space, the use of the floor space, the ceiling heights, the construction of the ceiling, the character of the work to be done, whether work will be carried on when daylight and artificial light will be required at the same time, due to the inadequacy of the daylight and the approximate number of hours under artificial light work is required. Plans giving this information in an entirely suitable form can be very simple. With these plans the work to be performed in each department should be carefully analyzed to determine on the requirements as to illumination. Will all of the light be thrown vertically downward or will the maximum amount of light be wanted in a horizontal direction or at an angle. After these requirements have been established as accurately as possizle without a practical demonstration, the total lumens required to furnish the illumination can be calculated within a reasonable degree of accuracy by the foot candle method.

With the approximate total lumens necessary known, we can then determine on the most satisfactory method of generating these lumens and the units to be used. Will the prime source of light be oil, gas or electricity? If the latter, what kind of lamp will be used and of what capacity? If the area to be illuminated is large, the ceilings high and the illumination wanted on the horizontal plane with no objection to shadows, then arc lamps or high capacity incandescent lamps with good reflectors can be used to advantage.

If the ceiling heights are moderate, the arc lamps may come into the direct range of vision, the illumination would be irregular unless an excessive number of lamps were used and the dense sharp shadows if arc lamps are spaced a sufficient distance apart to keep the "average illumination" normal may prove objectionable and smaller incandescent lamps or mercury vapor lamps may give the best results.

If the ceilings are low, the smaller incandescent lamps and the mercury vapor lamps will probably give the best results.

If the work to be done is large and coarse, where sharp shadows and irregular illumination are not objectionable, arc lamps spaced well apart could be used, whereas, if the work were fine requiring close and constant attention and a uniform illumination with few and soft shadows, if any, then incandescent lamps spaced close or mercury vapor lamps should be used.

If the lamps have to be located in the direct range of vision then the size of the lamp should be reduced to a minimum and all lamps should be provided with reflectors which will completely screen the lamp from sight and at the same time directs the light where desired.

In all cases if the maximum efficiency is to be obtained from the lamp, reflectors will have to be used to redirect the light and in all cases the bright light source must be covered by reflectors to prevent glare and to protect the operators from the fatiguing effect of sharp contrast and direct light in the eyes.

Having decided on electricity and the kind of lamp to use the next thing is the size of lamp and the spacing and in all cases the one will depend upon the others.

In calculating the number of outlets and the size lamp to use, the lamp should be the largest size possible to obtain the desired results, because the larger the lamp the fewer the outlets, the more simple and less expensive the wiring, but the more difficult the control. The smaller the lamp the greater number required, the closer the spacing, the wiring is more expensive, the control is more simple, the light can be more uniformly distributed and shadows eliminated.

Good judgment and experience must therefore be the guide in selecting the size lamp unless the construction of the ceiling makes a given number of outlets imperative when the size of lamp will depend on the number of outlets.

The size of the lamp selected should not require a spacing so great that the uniformity of the illumination is sacrificed. It is frequently better economy to use a smaller size lamp spaced sufficiently close to give a good uniform illumination without dark spots or sharp shadows and illuminating both the work and the surrounding floor area so tools, material and parts can be easily seen no matter where placed.

Where the ceiling construction does not determine the number of outlets, the size unit can be selected by finding which commercial unit will supply the required number of lumens by a satisfactory number of units. It is in this selection where the best judgment can be shown.

The size units determined upon the location of outlets is simple and outlets should be arranged so they will be symmetrical with the ceiling construction and so the outlets nearest the side walls are spaced sufficiently close to the wall to prevent dark corners and make available for work every foot of floor space.

Each outlet should be clearly indicated on the plan with the size lamp, the arrangement of circuits and method of control indicated so that the wireman will have no trouble in knowing just what is wanted, a bill of material and estimate of costs is always a great assistance, especially if you wish the material purchased to be installed by your own employees.

Up to this point we have used the foot candle or the watt per square foot method of calculation and it should be borne in mind that this method of calculation is simply an indication of what is required and what is desirable, and from this point on real illumination engineering will be essential. With the number of outlets and the approximate unit per outlet determined upon, it then becomes necessary to determine the equipment of the unit for the outlet, its mounting height, etc., and it is in this determination where the real skill of the illuminating engineer will be shown and in some cases to obtain the very best results possible, it may be necessary to put in several demonstration installations, that is, take several sections of the area to be illuminated and equip the outlets in each section in a different manner and then determine from the decision of the employees which method of illumination is the best adapted to the needs of the entire department.

As a general rule, however, this will not be necessary as the selection of mounting height and reflectors are dependent on whether all of the light is wanted in a vertically downward direction or a large percentage of the light is wanted at an angle or horizontally. If the light should be downward it is well to suspend the lamps as high as possible and get the desired distribution of light with the reflectors suitable, and as the quantity of light at an angle or horizontally increases the mounting height should be decreased and the type or reflector changed.

Nearly all reflectors come within one of three general groups. The focusing, those giving the maximum light with 10 or 15 degrees of the axis, the concentrator or intensive, those giving the maximum light between 15 and 30 degrees from the axis and the distributor or extensive, those giving the maximum light between 30 and 45 degrees from the axis.

With a spacing and mounting height suitable for a concentrating or intensive type of a reflector, the distributing or extensive type would give a slightly lower illumination intensity directly under the lamp, the illumination would be fairly even but a much greater amount of light would be thrown out at an angle whereas if the focusing reflector were used the light directly under the lamp would be greatly increased with comparatively large areas of low illumination intensity around this bright spot with little or no light at an angle.

The mounting height and type of reflector can therefore be changed to obtain any desired distribution of illumination but when results are obtained in this way it is always well to check back and see that the illumination intensity has not been excessively reduced.

In selecting a reflector due consideration should be given to the gloomy appearance of ceilings when opaque reflectors are used and the benefits derived from the presence of bright, cheerful ceiling, which can be obtained by using reflectors which transmit a small percentage of the light falling on their surfaces; also due consideration should be given to a reasonable diffusion or breaking up of the direction in which light rays fall on the work to prevent glare.

A reflector easily cleaned and not easily broken should always be selected because they have to be removed and cleaned frequently and experience shows that the best grade glass reflectors are entirely suitable for this purpose.

The reflectors and the mounting heights for each outlet should be indicated on the plans so the wireman knows what has to be done.

It is not only necessary to prepare such plans, but it is essential that work of installation be carefully supervised and checked to see that there is no departure from the plans and in cases where departures are necessary on account of the lighting unit located too near running shafts, pulleys or belts, or too near beams, girders or sprinkler systems. The departure from the plan should always be taken up with the Illuminating Engineer to see that the illumination results are not seriously affected by the changes suggested or so the change can be compensated for.

In many good layouts, the final results obtained have

proven unsatisfactory on account of unintelligent departures from the plans.

After the work has been installed it should be borne in mind that it will require careful and continued attention to see that lamps and reflectors are kept renewed and properly cleaned, because the efficiency of any lighting system will be greatly reduced if dirt and dust is allowed to accumulate on the lamps or reflectors. Regular inspection and cleaning are therefore essential if satisfactory results are to be obtained.

By providing adequate general illumination, the need of local or special illumination is reduced to a minimum and where local illumination is essential it should be provided with a lamp of the smallest candle power capacity for the work required,—these lamps should be protected by opaque reflectors to protect the employees eyes and where posible the lamp should be mounted in a permanent position on the machine to prevent loss of time in arranging the light. Local lighting is always special and each case should be treated separately depending on the machine and operation.

There are several fundamentals which should be borne in mind in planning any illumination system for an industrial plant.

In any industrial plant some means of working in the hours of darkness is essential and the difference in cost for an inadequate method and an entirely satisfactory method is usually a comparatively low percentage of the cost for the inadequate method.

In planning an illumination system for an industrial plant, it is essential that the light source be so located and protected that the tendency to accumulate dust and dirt is not above the average.

Light sources should be located where they are easy of access for renewal and cleaning. Light sources should be arranged so the direct rays of light from the lamp cannot enter the eye of employees.

When ceilings are high, larger units spaced at greater distances can be used without detriment, but when ceilings are low, the size of the units should be reduced because the distribution of light with low mounting heights is materially better from smaller units than from larger, and the harmful bombardment effect from smaller units is not nearly so great as from the larger units.

Circuits should be so located and controlled that those lights which are required first can be turned on the remainder and to obtain this it is necessary to have the circuit near the windows controlled separately from those in the centre of the rooms.

When artificial light is to be used with natural light as in dark parts of the works, or on gloomy days, late mornings and early evenings the artificial illumination must be excessive during the period when natural light is present in order to see comfortably.

A well lighted industrial plant will have less accidents than a poorly lighted plant so that proper illumination is an insurance against accidents.

The cost of a good lighting system is relatively low as compared with the cost of the building and equipment and as the building and equipment must be operated at maximum efficiency it is essential that the illumination system will provide for this.

The cost of operating the illumination system in an industrial plant is but a small percentage of the cost of labor or the value of the products produced. Therefore, the saving of a little time of the employees, a slight increase in quality or quantity of the output or, a slight reduction in the wastage due to spoiled material will more than offset the cost of operating the illuminating system. In one large industrial company it is estimated that the total cost of lighting for a month is paid for by saving six minutes of the employees time during the month.

In the construction of a new plant the proper wiring and control for the illumination system can be easily provided for, but in the remodeling of an old plant the installation of the illuminating system is not so simple and in many cases on account of economy in wiring it is essential that wiring and the light sources be located on the bottom of beams and girders which does not always give the best distribution of light possible to obtain, but if the proper size units and reflectors are determined upon, even these adverse conditions can be overcome. In some few cases it may be possible to run the mains below the girders and locate the light source in the bays of the ceiling between the girders and when this is done care should be exercised to see that the light sources are suspended sufficiently low that the girders do not cast objectionable shadows.

While it is not essential, it is well to give the light source the protection of a flexible method of suspension and with incandescent lamps this can be readily done by suspending the light source on a short piece of flexible cord which does not of necessity have to exceed three or four inches in length and then support the weight of the reflector on two or three short chains extending from the ceiling to the shade holder.

Too much emphasis cannot be laid on the necessity of keeping all lamps and reflectors renewed and thoroughly cleaned. The accumulation of dust or dirt greatly reduces the efficiency of the lighting unit and this dirt should be removed by a periodic thorough scrubbing with soap, brush and good hot water.

The circuits for lighting should always be independent from the power circuits and should be arranged to keep the line losses to a minimum under maximum load so the regulation of the illumination can be maintained within reasonable limits.

On account of the lateness of the hour it was impossible to discuss Mr. Fisher's paper, however, a vote of thanks was extended to him.

THURSDAY MORNING SESSION.

Mr. J. R. Sloan read the report of the Committee of Specifications as published in the October issue of the *Railway Electrical Engineer.*

Lamps.

Mr. Henry Schroeder (General Electric Co.) said that bulbs for 40 and 60 watt lamps shown as G—30, G—40 have been changed to G—25 and G—30.

Mr. B. F. Fisher (Westinghouse Lamp Co.) gave a lengthy discussion of the report and he stated that the Committee had done such excellent work that all railroads are fully justified in adopting it as a standard specification for lamps. After a rather lengthy discussion of the report by various members it was referred to letter ballot.

Wire.

Mr. W. A. Del Mar (P. R. R.) then read the report on wire as published in the October issue of the *Railway Electrical Engineer.*

Mr. F. J. White of the Okonite Company pointed out a slight discrepency in the thickness in the insulation called for is the minimum required by the National Underwriters for 600 volt service for this specification applies to volts as high as 750.

Mr. F. J. White objected to paragraph 12 A, 12 B and 12 D.

Mr. J. R. Sloan stated that Mr. White's objection was well taken and upon motion this paragraph was amended by adding the words "If such report is approved."

Mr. J. R. Sloan moved that a transcript of the remarks and criticisms be supplied the committee and that an attempt be made to incorporate with this report, as an appendix, the report of the Rubber Conference Committee on rubber compounds. The meeting then adjourned.

W. A. Delmar. (Communicated):

It may be of interest to hear a few words of explanation of Table III, which gives the high potential tests.

If the dielectric extended between two flat plates, the high potential test which would puncture it would be proportional to the distance between the plates. Where, however, the diaelectric is between two concentric cylinders, as in the case of an insulated conductor the electric stress becomes greater at the surface of the conductor, than elsewhere, its magnitude being expressed by the following equation.

V = K d log D where V = puncture potential, kilovolts. d = diameter of conductor, D = diameter of insulated conductor, over the insulation.

K = a constant depending upon the dielectric strength and some numerical factors depending upon the system of units, logarithms, etc.

Plotted against d, for a given thickness of insulation this equation gives a curve of the form shown dotted in the accompanying figure. This curve is, however, not available for practical use because a portion of the insulation is always rendered useless by the following circumstances.

1. Eccentric laying of insulation.
2. Reduction of thickness on outside of bends.
3. Irregularities due to crinkling of tape, etc.
4. Irregular form of conductors, especially if stranded.

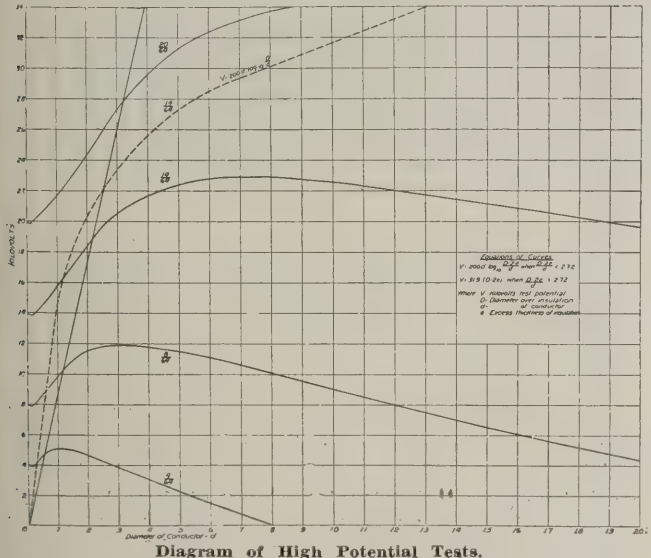


Diagram of High Potential Tests.

It is therefore necessary to amend the formula given above so as to allow for the above mentioned loss of insulation. It then becomes—

V = K d log D — 2e — d, where e is the useless thickness of insulation. The four full line curves in the accompanying figure are graphs of this equation down to the sloping line. To the left of the sloping line, the above equation does not apply. This fact was discovered and proved by Mr. W. J. Middleton, a member of our Committee, and we therefore call the sloping lines, the "Middleton Line." This line passes through the points where D — d = 2.72. The formula which applies to the points to the left of the Middleton line was suggested by Prof. Alexander Russel, reformulated by Mr. Middleton and proved by him from a large number of observations and tests. It is as follows:

V = C (D — 2e), where C is a constant. The values of the constants K and C were selected so as to submit the insulation to a testing stress not over one-fifth of the breakdown stress of high grade commercial compounds.

THURSDAY AFTERNOON SESSION.

Car Lighting Belt.

The report by the committee for rubber belting for axle generators was then read by Mr. L. S. Billau.

Mr. George B. Colgrove stated that after a thorough investigation the Illinois Central have adopted 4 ply belting as standard and are getting fairly better life than from the 5 ply belting previously used.

President Frost corroborated Mr. Colgrove's results stating that he had found that 5 ply belting was more apt to break at the belt clamps than the 4 ply.

Mr. C. M. Woodruff (Goodrich Rubber Co.) stated that it would require a fairly high grade belt to meet this specification. Mr. Woodruff pointed out that placing a badge plate every nine feet would involve considerable expense and a great deal of trouble and as the plate must be 1/32 in., in relief it would mean that there would be little if any pressure applied at this point during vulcanizing. This would cause weak spots in the belt. He suggested that if the badge plate were necessary it be specified that it shall be merely legible instead of standing out in bold relief.

Mr. J. R. Sloan stated that the only idea in having a badge plate was to identify each and every belt applied. It was suggested that this be made as an amendment to the committee report.

Mr. J. R. Sloan (P. R. R.) stated, that this is the first attempt ever made by consumers to draw up a specification for belting and he suggested that members of this Association should procure belting some time during the coming year manufactured under these specifications and compare the service obtained from that belting and the belting which they buy on the open market. This information could then be given to this Committee which he recommended be continued for another year. A motion that a report of the committee be laid on the table was carried.

Standards.

Mr. D. J. Cartwright read the report of the Committee on Standards as published in the October issue of the *Railway Electrical Engineer*. He stated that as a member of the Train Lighting Committee of the M. C. B. Association, he would request recommendations from this Association in regard to following points: 1st, standard design for straight axles carrying axle pulleys, 2nd. standard design for axle dynamo suspension, 3rd. standard design for battery boxes, 4th. recommendation as to the practice of maintenance of repairs of storage batteries.

Upon motion the new Committee on Standards was instructed to draw up a letter recovering these subjects and forward a copy of such letter to the representative to each of the various roads represented in this Association, in plenty of time so that a final statement could be made to the M. C. B. Association before their June Convention.

Mr. L. S. Billau suggested that the new Committee on Standards be instructed to take up the matter of standardizing the relative position between the filament of the lamp and the reflector.

Mr. W. A. Del Mar (N. Y. C.) suggested that the Committee on Standards be instructed to make a recom-

mendaion on standard forms for specifications, arrangement of headings, paragraphs, etc. The report of the committee was then accepted.

Mr. N. W. Storer of the Westinghouse Electric & Manufacturing Company then gave his paper on railway trunk line electrification.

Trunk Line Electrification

N. W. Storer.

It has been said that the delivery of transportation is the business of all railways. The source of the power required for this work is one of, if not the most, important elements that combine to produce this output. For many years the steam locomotive had absolutely no rival. It had a complete monopoly of the business and, like some other monopolies, it lacked the incentive of competition. Since the electric locomotive entered the field, however, there appears to have been a great awakening among steam locomotive designers which has delayed practically all electrification work, and possibly has prevented, for many years at least, the electrification of most steam railways. The improvements in the steam locomotive, such as mechanical stokers, super-heaters, smoke consumers, etc., have lead to the production of the enormous units that are now standard. These great machines have produced such excellent results that the electric locomotive has no longer such comparative advantages as were apparent even ten years ago; and, while I believe that the electrification of a large part of our railways is certain to be accomplished at some time, I also believe that the improvements in steam locomotives have removed the crying necessity for it, except in special instances, and that it would be a great mistake to compel the railways to electrify too rapidly. It would be far better for them to study the subject with the greatest care, finally to unite on the best system, and then proceed with electrification in places where there will be distinct economic advantages. In the electrification of the railways, in large cities especially, it is of the utmost importance that the railways should unite and give every plan the most careful consideration before starting the actual work. While this will delay matters for a while, it will be to the ultimate advantage, not only of the railways, but of the public and the manufacturing companies as well.

The manufacturing companies have done a tremendous amount of work in developing the various systems of electrification, and in the design of electric locomotives. They have learned many things about locomotives and in addition have come to a realizing sense of the fact that ten years ago they "knew some things that were not so." They have found that the low center of gravity in the electric locomotive, which was characteristic of the early types of electric locomotives, instead of being an advantage, is a decided disadvantage. They have also found that the fact that an electric motor develops its power by rotation does not necessarily make it easy for it to turn the wheels of a locomotive. It has been recognized for some years that one of the greatest, if not the greatest, problem in the electric locomotive is the transmission of the torque of the motor to the driving wheels.

It looks at first sight as if that would be a particularly simple thing to do, but when all the problems connected with it are considered, it rises to enormous proportions. There have been a great many combinations proposed and quite a large number of different types have been built and are now in operation, but there are few transmission systems that are absolutely satisfactory from all points of view.

In this respect, as in most others, every design is a compromise among the conflicting elements, not simply in the locomotive itself, but on the roadbed and shop as well. We recognize that, in proportion as a locomotive is built up around one idea in its design, it will be distorted, and other things will be neglected. We therefore realize more and more all the time the necessity for a careful study of the entire problem of railroading to enable us to produce the best type of locomotive. In this the heavier railway electrification is entirely analogous to that of the development of street railways. The early forms of railway motors and controllers were designed, to a great extent, in the laboratory, and it is surprising how little the designers really knew about what they were trying to do; but as time went on they became more imbued with the spirit of the operating man and they more and more got in touch with operating men and with the problem in general, and from the constant association with those men and the study of the problem right in the field, they have developed the street railway motors and controllers to their present high state of perfection. The same plan must be followed in connection with the electrification of railways. In the last analysis, all must agree that the best locomotive is the one that will deliver the transportation required of it with the lowest sum total of expense. This of course must include not simply the first cost and cost of maintenance and depreciation of the locomotive itself, but the first cost and cost of maintenance, depreciation and operation of the entire installation from power house to roadbed. It is because there is so little definite and reliable information on all these various subjects that there are so many different opinions concerning the systems of electrification and the proper design of locomotive.

It is my purpose to present to you a number of different designs of locomotives through the medium of lantern slides, and to describe briefly the several advantages attributed to each one of them. I do not claim that the list is complete, but it is sufficiently so to illustrate practically all the existing types.

I take it for granted that every one is familiar with the standard type of single reduction geared street car motor, which has one side carried by the truck and the other carried on the carried by the truck and the other carried on the car axle and has the power transmitted from the motor armature through a pinion to the gear which is keyed to the axle. The type of transmission has been eminently satisfactory for street car service, but the difficulties connected with it have increased enormously as power of motors and speeds have increased, until today it is generally believed to be poor practice to gear locomotive motors directly to the axles except for slow speed work. Several reasons have contributed to this belief:

(1.) The gears are subject to severe punishment when run at high speeds when rigidly connecting so much inertia as is contained in the wheels and armatures, and to still greater shocks from the roadbed. We have learned that in the operation of high speed railways using single cars or multiple unit trains, there has always been

more or less trouble from gears as soon as the speeds get up around fifty and sixty miles an hour. When such speeds are reached, the gears and armature both suffer, and there is always a very great increase in the cost of operation, especially if the track is poor. We have even found that the motor on one axle is subject to worse punishment than on the other. The trailing axle has the pinion of the motor pushing downward on the gear teeth, and the other axle has it pushing upward. The motor whose pinion is driving downward usually suffers much worse both in gears and in the armature windings, due to the blows that it gets from the roadbed. The wheel strikes a depression in the track that will suddenly lift the wheel as it climbs out, and it gives a direct shock to the teeth of the gear, that tends to retard the whole armature. This makes the gears for heavy high speed work unreliable, when mounted on axles.

(2) The dead weight of the motor on the axle, and its low center gravity, contribute to serious injury to the track when operated at high speeds. Chiefly, for these reasons, the speed of most locomotives, having heavy motors geared directly to the axles, is limited to about 30 M. P. H. Some locomotives of this type have been built for higher speeds, but practically none having motors larger than those used on heavy passenger cars has been used.

This grand type of locomotive is comparatively simple, cheap and easy to maintain, but when the design of a locomotive for high speed service is considered, the problems to be solved are many and difficult, and the solutions that have been offered are almost as numerous. It is of course an easy matter to design motors that are sufficiently large and powerful to equip any locomotive that is desired, so that that question need not enter into the matter to any extent. The big question is, how to connect the motors to the driving wheels so as to give a locomotive that will have a reasonable cost of maintenance, and at the same time, be a good riding machine; that is, one that will do the least possible damage to the track.

There are several general types of high speel locomotives:

(1) Those with motor armatures mounted rigidly on a driving axle. That is the type known as the New York Central type.

(2) Those with motors mounted on a quill surrounding the axle. That is the type of the original New Haven passenger locomotives.

Electric Locomotive Equipped with Scotch Yoke.

(3) The motor geared to quill surrounding axles, and connected to wheels through long helical springs. That is the latest type of locomotive of the New York, New Haven and Hartford, and the Boston & Maine Railways. Such a locomotive was on exhibition here two weeks ago at the electric railway convention.

(4) Motors mounted in the cab and driving through a jack shaft and a system of parallel rods. That is the type adopted by the Pennsylvania Railroad.

(5) Motors mounted low between frames and connected to the drivers through a Scotch yoke. That is the type of the Italian three phase locomotive.

(6) Motors connected to the wheels by some combination of gears and side rods. That is the type used in the Loetschberg Tunnel in Switzerland, and the Midi Railway in France.

The first type named may be called an example of a locomotive built around one idea, namely, that of mounting the armature of the motor directly on the axle, and building the motor field into the truck frame so as to do away with all motor bearings. It is a scheme that is ideal in its simplicity, and it is not surprising that the N. Y. C. R. R. desired to use it. However, it is well known that the locomotives have never been considered

as successful high speed machines, on account of the tendency to nosing, which destroys the track. A great many steam locomotives have some tendency to nosing, but it is not serious, as the mass of the locomotive is located so high above the rail that the wheels may follow any irregularities in the track without disturbing the mass of the locomotive, and consequently, with the minimum of strain on the rails. This type of electric locomotive has an extremely low center of gravity, so that it is quick to feel the irregularities in the track, and synchronous vibrations are very easily set up. A great deal has been done to eliminate this defect, but the efforts have been only partially successful.

The second type mentioned—that having the motor mounted on a quill surrounding the axles and connected through springs, is open to some of the same objections as the first type. This also has a low center of gravity, although considerably higher than the first type, but all weight is spring-supported so that the track does not get a direct blow. The original New Haven locomotives nosed badly at high speeds, but were entirely cured by the addition of an idle axle at each end of the locomotive and a toothed cam centering device between the cab and the trucks. These locomotives now exhibit absolutely no tendency to nose at even the highest speeds—75 to 80 M. P. H.—where formerly they nosed at 50 to 60 M. P. H. However, even with the motors carried by springs, the track is liable to damage unless it is kept in good surface.

The third type,—having motors mounted above and geared to quills surrounding the axles, is one of the latest developments, and the New Haven locomotives of this type are the easiest riding electric locomotives that have ever been built. Mounting the motors rigidly on the trucks, above the axles and gearing down to the quills, of course raises the center of gravity very considerably. Then the long helical springs connecting the quills to the driving wheels permit the axles and journal boxes to move a total vertical distance of 3 inches in the pedestal jaws, without the quills touching the axles. Thus the wheels are free to follow the inequalities of the track without disturbing the mass of the locomotive, and consequently with the least possible damage to the track. The arrangement of wheels shown in figure, combined with the distribution of weight and the drive, entirely prevents nosing, and the secondary springs transmitting the weight of the cab to the trucks through the large surface plates prevents the transmission of vibration from the truck frame to the cab and makes the cab ride like a Pullman car.

This type of locomotive has been built, both with a single motor per axle, and with twin motors of the same total capacity per axle. After building a number of the former, whose motors were so large as to require double gears, it was found that the same output could be obtained, with less weight and less cost, but substituting two motors for the one large one. This arrangement has the following advantages:—

(1) Only one gear is required, as both motors drive through the same gear.

(2) The two motors are lighter and easier to handle, and cheaper to maintain than the large one.

(3) The motors in this case are interchangeable, except field castings, with the motors used on the New Haven multiple unit cars.

(4) Two motors being connected permanently in series gives in effect one motor of double voltage and consequently half current. This reduces the carrying requirements of cables and switches to one-half, and thus makes a substantial saving in the cost of control equipment.

The gears on any of these locomotives have never given a moment's trouble. The spring drive removes the bad effects of the impact of the teeth when operating at a high speed, so that it is anticipated that the gear speed may be much higher than that of the ordinary gears mounted directly on the axles.

Gears mounted directly on the axles, when properly lubricated, usually wear out more than the impact of the teeth than from friction. Therefore, in avoiding the face of the impact by driving through springs, the life will be greatly increased. The efficiency of such a great drive is very high.

While these locomotives are now built for single phase operation, they would have practically the same advantages on direct current. The twin motor scheme adapts itself well to high voltage D. C. operation.

The fourth type of locomotive—that with motors mounted high up in the cab and connected to drive wheels through cranks, parallel rods and jack shaft, is the type adopted by the Pennsylvania Railroad for the New York Terminal. They have a very high center of gravity, and, although the weight on driving axle is about 56,000 lbs. and the springs are consequently stiff, the locomotive has excellent riding qualities, corresponding to the best steam locomotives. There is absolutely no tendency to nosing, and no bad effects on the track. These locomotives are the most powerful electric locomotives ever built, and have shown themselves to be wonderfully reliable, having a record for the first year with 33 locomotives in series of 13 train minutes delay, chargeable to the locomotives. They have a guaranteed tractive effort of 60,000 lbs. and have actually developed over 75,000 lbs. at the draw bar. This corresponds to a crack-pin pressure of over 100,000 lbs. Of course, the normal pressure on crank pins is not nearly so high, but it is sufficient to impose strains on the jack-shaft bearings that are very hard to hold. The strains on the jack-shaft bearings are worse than reciprocating—there is scarcely any neutral zone there, because of the combination of strains imposed upon it by the motor rods and driving wheel rods acting at an angle of about 45° from each other. This angle, however, is much to be preferred to the vertical motor rods adopted for the first locomotives built for the German State Railways. These were practically failures, and we understand that future locomotives will have motor rods arranged similarly to those of the Pennsylvania. It has been found that locomotives of this type require very careful adjustment to maintain the shafts parallel and properly centered and quartered.

The use of side rods on an electric locomotive introduces some different problems from those found in the steam locomotive. As there are no reciprocating parts, such as piston rods, the parts are susceptible to perfect balance, which is usually impossible in the steam locomotive. The rods must be very much larger than for corresponding steam locomotives, because the entire power has to be transmitted through one set of pins and rods at certain points in the revolution, while the steam engine transmits the power from only one cylinder. The steam engine has another advantage in that the main rods on the two sides of the locomotive are connected to loose ends, while the rods on the two sides of the electric, are connected to opposite ends of the motor shaft, as well as the jack shaft, which introduces a great many chances for inaccurate workmanship in quartering and tramming and consequent knocking in the pins and bearings. This has been the case with practically every one of this type that has been built. Nevertheless it is the type that is preferred by many railway men for high speed work, and will probably be used a great deal on

account of the similarity to the steam locomotive, both in design and performance.

The fifth type of locomotive—that employing the Scotch yoke for transmitting the power from the motors to the driving axles, has been used exclusively for the three phase locomotives on the Italian state railways. The first ones have been in service some 10 to 12 years in the Valtellini line, and have given excellent results. The later ones, some 35 in number, have been used about two years on the Giovi line near Genoa. These machines have some excellent qualities,—light weight, powerful motors, and motor weight entirely spring supported.

They have, however, been used only in slow and moderate speed service, so their performance at high speeds remain to be proven.

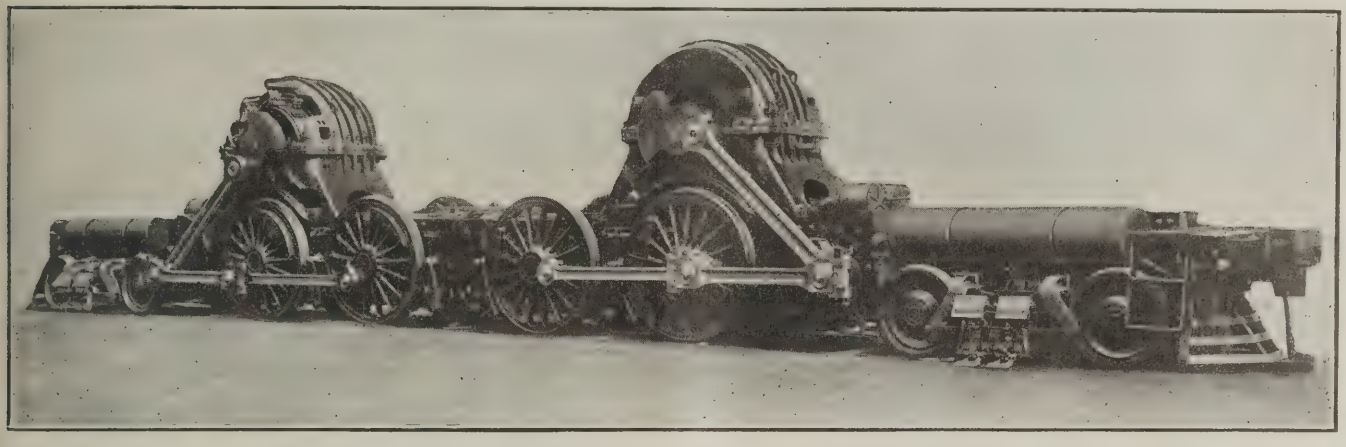
These locomotives also require very accurate adjustment, although not so close as the one with side rods and jack shafts, as the Scotch yoke drives one axle through a sliding block and the others through parallel rods connected to the yoke by knuckle pins. Spherical crank and knuckle pins are largely used with this type of drive.

The sixth and last type mentioned, is the one driving the locomotive through a combination of gears and side rods, or gears and Scotch yokes. A number of such locomotives have been built, the most notable being the one built for the Loetschberg Tunnel in Switzerland, and for the Midi Railway in France. The former has two 1000 H. P. motors, each connected by a helical tooth gear to a jack shaft, which is slightly above the driving axles, and thence by parallel rods, to three pairs of driving wheels. Although the motor speed is extremely high, the gears operate practically noiseless and with high efficiency. The duty on the jack shaft bearings is much easier than when side rods only are used, since the reciprocating pressures are practically all in a horizontal direction, and can therefore be cared for much more easily. The Midi locomotive, built by the Societe Anonyme Westinghouse, has two motors, each geared to a jack shaft through gears located outside the plate frames of the locomotive. The jack shafts are connected to the drive wheels through Scotch yokes like the Italian locomotive. Either of these types has a fairly high center of gravity and is therefore susceptible of a design that will have excellent riding qualities. While either locomotive is subject to criticism for having both gears and side rods, it must be admitted that the arrangements for both are such as to give the best results.

The motors, and everything else, being located above the springs, the duty of the gears is less severe than if they were mounted on the axles; consequently they should have a long life. The jackd shafts for side rod drive should be located in the same horizontal plane as the driving axles, consequently the problems connected with tramming and quartering, and with bearings, are reduced to a minimum. In some respects this design is superior to either straight geared (gears on axles) or straight side rod types, and it is probable that a good many locomotives with gears and side rods will be built.

The twin motors may be used here, thus reducing the gears to the lowest number, or the smallest width of face.

In the foregoing pages, but little has been said about the electrical features of the locomotives, and nothing at all concerning the suitability of different electrical systems for railway electrification. As a matter of fact, any of the types of locomotives described, except the New York Central type, might be equipped with apparatus for any of the known systems.



Running Gear of Locomotives Furnished for Pennsylvania Terminal.

The New York Central type is suitable for direct current only. The New York, New Haven & Hartford locomotives of both types described are operated with single phase alternating current motors on both A. C. and D. C. circuits. The Pennsylvania locomotive is for direct current, but locomotives of similar type are built in Germany for single phase lines. The Italian locomotives are all for 3-phase operation. The combination gear and side rod locomotives named are both equipped for single phase operation.

While most of these locomotives are equipped with alternating current motors, this is true only because it has been believed that alternating current is better suited for heavy trunk line electrification, and therefore most of the heavy locomotives have been designed on that basis.

If the choice of system rested only on the locomotive, undoubtedly the standard 600 volt D. C. system would be chosen in the large majority of cases as being the simplest and best adapted for the work, but for the electrification of a trunk line, this is an economic impossibility. It is impossible because the low voltage requires too great an expenditure for substations and gives a low efficiency except in a traffic which gives a good load factor. It is possible only with a third rail system, on account of the enormous currents required.

In order to reduce the number and cost of substations, the voltage must be increased to a point that would prohibit the use of a third rail, even if it were not otherwise undesirable. It is therefor generally accepted as a fact that the current must be taken from an overhead trolley. It then becomes a question as to how much current can be collected from an overhead wire, and this is really the most important of any. It is comparatively easy to collect 150 to 200 amperes at slow speeds with the ordinary trolley wheel. The same wheel can collect, for a few seconds, as much as 400 or 500 amperes, but

deteriorates rapidly with such currents. It is probably safe to say that a current of 200 to 300 amperes may be continuously collected at high speeds, either by wheel or some form of roller or sliding shoe. The wheel can scarcely be considered for high speed locomotive work, for obvious reasons, but both roller and sliding pantagraph trolleys have been used.

It is of the greatest importance in high speed service to have the overhead construction very flexible and to have the current collectors light. Otherwise there will be a great deal of flashing, and the wire will receive a kink at every suspension points that will soon cause it to break. Further, the number of collectors in a single span should be limited so as to prevent the entire span from being lifted. All these things tend to limit the amount of current that can be collected for a single train, and consequently to raise the voltage.

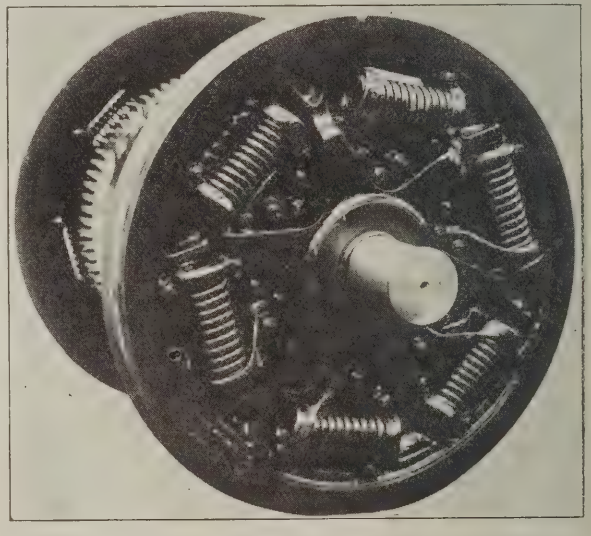
We have been required to give quotations for locomotives of over 3000 horse power capacity. It will probably be necessary at times to operate two such locomotives in a single train. Even with one of them operating at 3000 H. P., a current of about 750 amperes would have to be collected with a voltage of 3500 D. C. on the line. Granting that two collectors might be used, the current per collector would still be close to, if not beyond, the range of anything that has been successfully accomplished up to the present time in high speed service. It is my belief that 3500 volt direct current is about the lowest voltage that should be considered for high speed trunk line service, on account of the difficulties of current collection. Lower voltage will, of course, be used for lighter and slower speeds service. Whether locomotives can be made commercially with this high voltage, remains to be determined. Even if locomotives were to be built, however, it is very certain that such a voltage is entirely beyond the range for multitple unit car operation, so that any line with 3500 volts D. C. on it, would be confined to locomotive service.

The single phase system is the only one that has successfully solved the problem of current collection at high speeds. The usual voltage for heavy railway work in this country is 11000. In Europe it is even higher—15000 for the Loetschberg tunnel line, and this will probably also be used in Germany in the electrification of the State Railways. Either voltage makes it a comparatively simple matter to collect the current necessary for the heavy high speed trains.

The New York, New Haven and Hartford R. R. Co., which is using the 11000 volt single phase system, is steadily extending its electrification. It is practically the only company that is making such extension. They have the Oak Point yards and the Harlem River division equipped now and they are doing their switching with electric locomotives. They have suburban service on the New York, West Chester & Boston Rwy., and they are rapidly extending the main line electrification to New Haven, so that in a very short time they will run from New York to New Haven with electric locomotives. At the same time, they are figuring on the line from Boston to Providence, which will probably soon be electrified. Such extensions indicate that the system is satisfactory.

Running Gear of Motors Furnished for Hoosac Tunnel. A Single Motor per Axle with Gear Drive.

There are one or two railways in the west to be electrified with 2400 volts direct current, which will also give us a line on that system. At present it is more or less experimental.



Driving Wheels of the Hoosac Tunnel Locomotive.

Discussion of Paper on Electrification.

Upon being asked as to the frequency generally employed in single phase installations, Mr. Storer stated that in this country only one installation was operated on anything but 25 cycles, while in Europe most of the work was now being carried on with 15 or 16 2/3 cycles. He stated that in the lower frequency it is possible to get a larger output from the motors but this is offset by the fact that the transformers are much heavier. The transmission line characteristics of the 15 cycle system are somewhat better than the 25 cycle.

Mr. W. A. Del Mar (N. Y. C.) stated that he had been making some estimates on the cost of electrification, comparing the direct current and single phase system, using the actual cost of line material, locomotives and cars. The net results of his investigation he stated were as follows: If the line is short and has a high density of traffic the d. c. system is invariably cheaper with both first cost and operating cost, but where the traffic is

comparatively light or extends over great distances the a. c., system is cheaper. He stated that this was because of the fact that the apparatus distributed along the right of way is very much less in the single phase system than with the d. c., system. On the other hand, the cost of rolling stock is much more expensive with the a. c., system than it is with the d. c. He inquired from Mr. Storer, what the prospects of a reduction of cost of the single phase locomotive was.

Mr. Storer stated that the higher cost of the single phase apparatus is inherent with the design of the motors. The fields must all be full laminated and the armature windings are more complicated and more expensive than in the d. c., motor. He stated that another very important element in costs is the comparatively small amount of single phase apparatus that has been built at the present time. When these are built in larger quantities there will without any doubt be a marked reduction in price.

As to the comparative cost of the electric locomotive with the steam locomotive, Mr. Storer said that in ordinary sizes the cost of the electric locomotive would be about double that of the steam locomotive, but on the other hand it would be able to do twice as much work. He also pointed out that while the cost of electric locomotive was steadily decreasing, the cost of the steam locomotives were steadily increasing on account of the added complication of mechanical superheaters and smoke stokers, smoke consumers, etc.

Mr. Willard Doud (I. C.) stated that the larger sizes of the locomotives compared, the more nearly they approached the same figure. He also pointed out the fact that the maintenance cost of the steam locomotive runs about twice as high as any electric locomotive and as stated, Mr. Storer it is possible to get about twice as much work from an electric locomotive as from a steam locomotive.

A vote of thanks was extended Mr. Storer for his excellent paper and the meeting adjourned.

(The paper on Postal Car Lighting and the occompanying discussion are given on page 196.)

5TH ANNUAL BANQUET.

The fifth annual banquet of the Association of the Railway Electrical Engineers was held in the Gold Room of the Congress Hotel, Thursday evening, October 24th, 1912. Frederic P. Vose of Chicago, General Counsel of the National Credit Association, acting as toast master.

Mr. Vose is an old friend of the Association and when it comes to extracting laughs and giggles from the assemblage his equal can't be found this side of the Alleghenеys. To those who were at either last years' banquet or this years banquet, it is enough when we say Mr. Vose was up to standard.

The toast master then called on Mr. Robert Quayle, General Superintendent of Motor Power, C. & N. W. Ry., who five minute before his toast, told the writer he didn't have the slightest idea of what he was going to say, but he managed to give a most excellent talk. He said that he was especially pleased to note the broadening of the interests and the scope of this Association from that of simply car lighting, to cover the many other applications of electricity to railroad operation. He said that the railroads of the future would undoubtedly run trains from ocean to ocean by electric motive power.

Later the toast master called on a gentleman of rather Dutch accent but who hailed from the Jacksonville & Keywest Railway who turned out to be one of the best laughs of the evening. He talked about politics, Adam and Eve, the high cost of living, in fact everything but electricity and railroads.

Mr. F. R. Frost, Electrical Engineer of the Sante Fe and the retiring President of the Association was called upon for an address and outlined in an excellent manner, the work and scope of the Association. He thanked Mr. Quayle for his words of appreciation and encouragement of the work done by the Association. In behalf of the Association the Railway Electrical Engineers, he extended a vote of thanks to the Railway Electrical Supply Manufacturers' Association and all others who had contributed to the success of this convention.

The toast master then called upon Mr. George Porter of the Railway Supply Manufacturers' Association in which George tried to slip one over on our worthy toast master in a story about a guy being electrocuted because he couldn't stand for a five minutes talk from Mr. Vose. This was handed right back to George, however, hot off the bat by our worthy toast master. After a vote of thanks to the banquet committee the hall was cleared and the annual ball of the Association was begun.

ENTERTAINMENT.

The entertainment features this year were right up to standard. On Monday night, October 21st, a large party of railroad men and supply men with their ladies assembled in the dance hall on the 9th floor of the Auditorium Hotel. This was unusually well attended and everybody seemed to have a good time.

On account of bad weather on Tuesday it was necessary to postpone the automobile tour until Friday, but on that day a score of cars took the ladies of the Convention for a tour of the parks and boulevard system of the city.

Tuesday night was ladies' night for viewing the exhibits and we were right on our Bon Bon prophesy of the last issue. Needless to say the ladies enjoyed themselves. On Tuesday night a party of men interested in the subject of round house lighting was organized and made a trip to the new Chicago and North-Western round house at Proviso, Illinois, which has the headlight system of illumination.

On Wednesday afternoon the ladies of the Convention enjoyed a theatre party at the Olympic. "The Man Higher Up" was played.

Thursday evening the 5th annual banquet of the Association was held in the Gold room of the Congress Hotel. This room, which is one of the largest banquet halls in Chicago, was filled to overflowing with the 475 guests attending. Mr. Frederic P. Vose acted as toastmaster and to those who have heard Mr. Vose before, the mere mention of his name is a sufficient testimonial. Mr. Robert Quayle, Gen. Supt. of M. P. of the C. & N. W. Ry.; F. R. Frost, Elec. Engr. of the Santa Fe, retiring president of the Association of Ry. Elec. Engrs; George H. Porter, retiring president of the Manufacturers' Association, and Mr. Louis Wagner, ostensibly from the Jacksonville and Key West Railway, offered toasts.

After the banquet tables were cleared away and the annual ball of the Association held sway until the wee hours of the morning.

Friday afternoon the Illinois Central R. R. took the members of the Association for a tour of inspection through its Burnside shops. Several pictures of the visiting party were taken by a member of our staff, and are given in another part of this issue.

Those Who Registered

Jr. and Sr. Active.

A. C. L. R. R. Co.
Chas. R. Sugg
A. T. & S. F. Ry.
F. R. Frost
S. W. Everett
H. G. Myers
Raymond H. Osman
Jos. G. Prantle
Richard Hamilton
W. T. Perney
C. B. Jennings
Porter M. Mitchell
B. & A. R. R.
L. B. Knight
B. & O. R. R.
L. S. Billau
Clarence R. Reynolds
A. H. Swerzey
Alexander Summers
James Donoghue
Norman G. Wolf
Harvey F. Winters
Chas. E. Singer
Jos. Sidney Smith
Canadian Pacific
E. S. MacNab
C. B. & Q. R. R.
H. A. Gardiner
Fred McGary
Geo. G. C. Elbreder
Chicago Indiana & So.
N. E. Greenawalt
C. M. & St. P. Ry. Co.
C. R. Gilman
H. J. Frenk
C. J. Lundquist
C. R. I. & P.
F. E. Hutchison
R. W. Pachaly
M. K. Holland
W. M. Beardslee
Geo. M. Price
W. T. Tibbetts
J. G. Eberler
H. D. Andrews
A. B. Gidley
E. Rubedew
H. W. Gammell
J. Schulter
J. N. North
E. Dohney
E. P. Denham
H. R. Pennington
Johnu C. Willms
Christ Willms
George H. E. Wachter
S. Smith
E. U. Roland
Thos. Larkin
Edgar Johnston
C. G. W. R. R.
Geo. R. Shirk
P. J. Wynick
C. & A. R. R.
C. L. Abrams
Anton Abramic
W. W. Chance
C. & E. I. R. R.
H. J. Burcham
C. & N. W. Ry. Co.
A. J. Farrelly
Jos. A. Andreucetti
Geo. E. Murray
Chas. Arenza
L. W. Stephens
F. F. Haves
J. M. Hamer
A. J. Johnson
A. A. Kemp
F. E. Mead
W. C. Cadwell
L. C. Buchholz
C. & W. I. R. R. Co.
John L. Ohmans
J. W. Perry
Christy Peters
E. R. Duffin
A. R. Wicklander
Joseph Wright
R. C. Kelly
St. L. & St. R. R.
L. C. Hensel
O. G. Williams
I. C. R. R.
E. W. Jensen
Willard Doud
G. B. Colegrove
J. C. Younger
I. C. McElree
C. B. D. Mugan
J. C. Timewell
Harry Aregood
C. M. Gallaghar
M. R. Garnett
R. T. Fancher
R. T. Shipway
B. W. Sackett
Chas. Schneider
Chas. A. Shipnay
A. Huber
C. E. Harris
T. H. Hopkins
J. D. McElree
Gary G. Harris
J. A. Hamilton
F. H. Luittich
J. Landorff
J. H. Brown
C. A. Jansen
L. A. North
Frank Maginel
G. P. Nelson
George Nelson
William Mechan
Fred Kamp
J. H. Wickman
K. Cy. Term. Co.
Swenson
Lake Shore & Mich. So.
H. C. Meloy
I. R. Wentworth
Bert H. Ehringer
A. Engelsohn
Chas. O. Der Casse
C. L. Collins
L. V. R. R.
D. J. Cartwright
Michigan Central
L. L. Altstatt
Wm. F. Lietzan
Mo. P. Ry.
H. F. Pfeffer
N. I. G. & E. Co.
John Fogarty, Jr.
N. Y. C. & H. R. R. R.
Wm. A. Del Mar
Alex. M. Gary
H. W. Smith
Norfolk & Western
C. H. Quinn
O. S. L. R. R.
H. R. Bucks
Penn. R. R.
J. R. Sloan
Daniel B. Pastorius
C. J. Causland
Daniel C. Thwartes
W. T. Griffin
John C. Snyder
W. H. Sherbondy
W. H. Keirn
I. M. Craig
I. L. Minicke
Pullman Co.
N. E. Lemmon
P. L. Pflager
Geo. H. Scott
J. F. McLaughlin
Frank L. Brown
R. M. Lytle
W. Anundson
C. C. Oberly
C. R. Thompson
Norval Thompson
G. A. Smith
Jno. Larelle
J. A. Larson
F. W. Weaver
C. Krech
Arthur Meyers
R. F. Cram
Ben Callahan
M. B. Osburn
Phila. & R. Ry. Co.
H. A. Stofflet
Soo Line
G. R. Smith
Southern Pacific
E. M. Cutting
Union Pacific R. R.
A. J. Collett
Washington Terminal
James B. McIntosh

Associate.

Adams Bagnall Co.
B. A. Stowe
C. W. Beach
A. J. Selzer
Adams & Westlake Co.
R. M. Newbold
American Circular Loom Co.
T. C. Hawkins
George C. Richards
Geo. A. Lutz
Central Electic Co.
Chas. E. Brown
J. M. Lorenz
Dan Woodhead
J. R. Oleson
J. J. J. Harley
R. N. Baker
American Conduit Mfg. Co.
Frank R. Bryant
American Pulley Co.
Morris W. Rudderow
Appleton Elec. Co.
R. P. Tillotson
Benjamin Elec. Mfg. Co.
W. E. Watson
Columbia Inc. Lamp Works
S. D. Oldham
Crouse Hinds Co.
F. F. Skeel
Carl A. Bissell
E. G. Smith
Walter M. Fagan
Cutter Elec. & Mfg. Co.
C. E. Wise
W. T. White
Geo. Cutter Co.
O. B. Duncan
Consol. Ry. El. Lt. & E. Co.
L. J. Kennedy
Delta Star Co.
C. R. Laninger
Diehl Mfg. Co.
H. H. Smith
Economy Fuse Mfg. Co.
A. L. Eustice
Edison Storage Battery Co.
H. G. Thompson
F. V. McGinness
G. F. Wakeman
Electric Storage Battery Co.
H. E. Hunt
Godfrey H. Atkin
R. Baird
Elec. Testing Lab.
Preston S. Miller
Normal D. Macdonald
Esterline Co.
George Bell
Flexible Steel Lacing Co.
Geo. F. Purple
Ft. Wayne Elec. Works
C. A. Cummings
General Electric Co.
J. Scribner
J. O. Witherbee
O. A. Hain
L. L. Parker
Getts
C. M. Langfield
Buchanan
A. L. Broe
C. H. Jones
Allen G. Jones
C. C. Douglas
Jack Cross
Gould Coupler & Storage Battery Co.
Geo. Milne
Wm. F. Bouche
G. R. Berger
Wm. T. Sherman
S. D. Cowe
Hess Bright Mfg. Co.
W. L. Batt
Independent Lamp & Wire Co.
Richard S. Carrick
Ray P. Lee
H. W. Johns-Manville Co.
E. A. Hurlbut
Kerite Ins. Wire & Cable Co.
Azel Ames
B. L. Winchell, Jr.
P. W. Miller
J. W. Young
G. A. Graber
B. A. Fuller
Main Belting Co.
Wilbur E. Fawcett
National Lamp Asso. Elec.
C. W. Bender
Jas. A. Hamilton
National India Rubber Co.
P. F. Lyons
National X-Ray Refl. Co.
Harvey B. Wheler
F. H. Aldrich
Nelite Works of Gen. Elec. Co.
Arthur J. Sweet
L. C. Doane
J. W. Foster
Standard Underground Cable Co.
Russell Green
Okonite Co.
Francis J. White
W. G. Hovey
Oliver Elec. Co.
F. W. Oliver
Oneida Steel Pulley Co.
Nelson G. Stark
Pass & Seymour, Inc.
V. R. Despard
Frank T. Hoffman
Pocket List of R. R. Officials
Charles L. Dinsmore
Pyle Nat. Elec. Headlight Co.
H. John Kilker
H. B. Bayless
Chas. W. Dake
C. P. McGinnis
Railway Electrical Engineer
Edward Wray
Geo. W. Cravens
Wm. C. Robinson & Son Co.
C. G. Swank

Safety Car Heating & Lighting Co.
J. G. Van Winkle
Geo. E. Hulse
Lindsley Schepmoes
C. E. Miller
H. H. Halm
C. A. Pinyard
J. H. Rodger
S. K. F. Ball Bearing Co.
Frederick H. Poor
C. O. Winn

Sangamo Electric Co.
J. H. Hadde
Terry Steam Turbine Co.
A. P. Peck
Thompson Electric Co.
Allison J. Thompson
U. S. Light & Heating Co.
W. L. Bliss
W. P. Hawley
W. F. Bauer
J. E. Widner

Victor Balata & Textile Belting Co.
Jos. L. Abt
Western Electric Co.
Geo. H. Porter
H. F. MacGuger
A. C. Keene
Westinghouse Electric & Mfg. Co.
B. F. Fisher, Jr.
N. W. Storer
Arthur J. Cole

J. H. Bryon
R. E. Schaulin
L. A. S. Wood
R. E. S. Geare
A. N. Brown
W. H. Beattys, Jr.
Willard Storage Battery Co.
W. E. Ballantine
F. S. Gassaway
C. A. Burrell
Louis Sears

The Convention Exhibits

Adams-Bagnall Elec. Co., of Cleveland, showed Jandus fans and Abolites. Mr. B. A. Stowe and C. W. Beach were in charge of the exhibit.

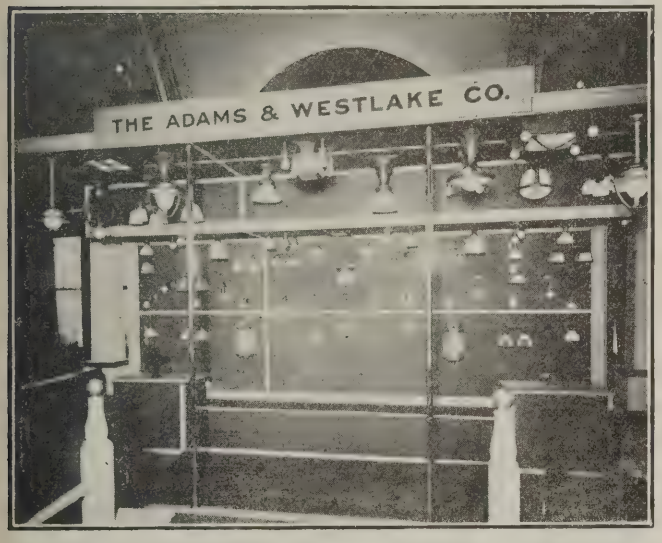


Exhibit of The Adams & Westlake Co.

The Adams & Westlake Co. showed a complete line of car lighting fixtures which were mounted on a large and very attractive booth representing a car. These fixtures included in all 73 different types varying in size from the small limousine lamp to the large 75 watt center deck unit. They showed semi indirect and consealed types for both coach and postal car lighting. All of the various types of glassware manufactured were shown. Mr. G. L. Walters, R. M. Newbold, and J. W. Mercer represented the Company at the Convention.

The American Pulley Co. showed both their flange and flangeless type axle pulleys and their new steel bushing and also a pressed steel car wheel for inspection cars. This company now makes a pressed steel car wheel which will accommodate any of the standard roller, ball or packed bearings.

As a convention souvenir they distributed a beautifully bound flexible morocco booklet giving considerable information on axle pulleys. As an appendix to this

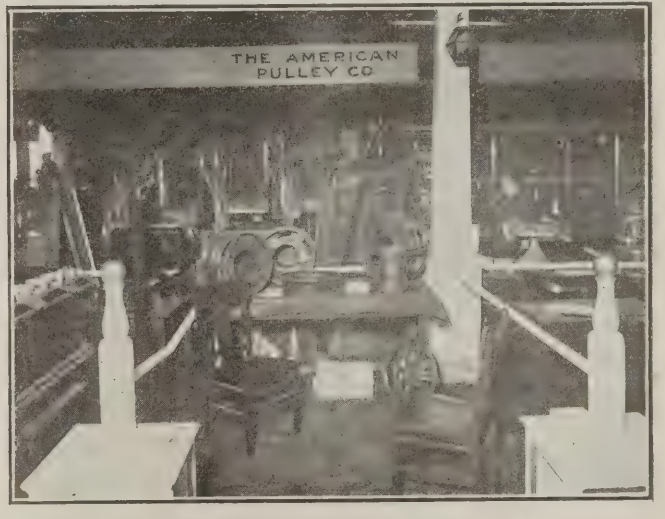


Exhibit of the American Pulley Co.

booklet was some important information regarding belt tension with different sizes of generators for both 17 in. and 21. axle pulley. Mr. M. W. Rudderow, John Forrest and C. P. Englehart represented the Company at Convention.

Exhibit of The Appleton Electric Co.

The *Appleton Electric Company* of Chicago had a very attractive exhibit covering their new line of stamped steel unilets, etc. This company has now specialized on drawn steel fittings to replace their original line of cast iron fittings. They are thoroughly sherardized and are provided with porcelain covers which fit snugly to the unilets. R. P. Tillotson represented the company.

Benjamin Elec. Mfg. Co. showed a complete line of industrial lighting fixtures and reflector sockets. Their booth was one big glare of light with a big 1000 watt tungsten mill cluster and a 500 watt reflector socket with numerous other fixtures. A new feature of particular importance was their angle type reflector socket which may be used to advantage in certain cases where it is desired to have the maximum flux of light directed at an angle from the perpendicular. This is furnished in all sizes up to 500 watts. They also showed a portable lamp guard for roundhouse and shop use which is both ground proof and of sturdy construction to withstand severe service.

One feature of particular interest to the car lighting engineer was their new spring clamp fixture which securely grips the neck of the reflector by a twist of a

Exhibit of the Benjamin Electric Co.

cam ring. This is then locked with a set screw so the fixture cannot work loose. H. E. Watson, A. E. Lubeck, and G. B. Webber were in charge of the exhibit.

Central Electric Co. exhibited a complete line of Columbia Lamps, Okonite wire, Opalux glassware, Diehl car fans of both ventilating and exhaust types, D. & W. fuses, Gibbs connectors, Ralco charging plugs and connectors, Crouse Hinds headlights and magazine fuse holders. Chas. E. Brown, J. M. Lorenz and R. N. Baker were in charge of the exhibit, while Messrs. Hovey and White represented the Okonite Company, and Mr. C. D. Oldham represented the Columbia Incandescent Lamp Works.

Crouse Hinds Co. To the car lighting man, the exhibit of the Crouse Hinds Co. probably contained more information and more new devices of interest to him than any other exhibit on the floor. They showed their new axle generator condulet connector for connecting axle generator leads to the regulator circuits of the car; and changeable side junction box in which a blank side plate, a one-hole or a two-hole side plate of any desired size may be inserted as required. A new yard charging plug and receptacle, to be described later in the December issue, and battery box fuse condulet for mounting on battery box beneath the car, were also shown.

They also showed a complete line of condulets for interior conduit work; the standard New York Central and the standard Santa Fe switchboard panels; and also a plug and receptacle for portable leads as used in round houses, machine shops, etc. F. F. Skeel, E. G.

Exhibit of the Central Electric Co.

Smith, A. F. Huels, C. H. Bissell, and C. M. Crowfoot represented the firm at Convention.

Cutter Elec. & Mfg. Co. showed a line of circuit breakers of various types for railway, power station, and shop service. H. F. Darby and C. E. Wise were in charge of the exhibit.

Exhibit of the Crouse-Hinds Co.

Economy Fuse & Mfg. Co. showed a full line of refillable fuses of from 1 to 600 ampere capacity, and both 250 and 600 volt types. For purpose of demonstration they showed one fuse with a side cut away to show the fuse links which are the refillable element of this fuse. This also showed the ventilating features of the fuse which prevents fire flashing out when the fuse is blown. Mr. E. L. Eustice was in charge of the exhibit.

Exhibit of the Economy Fuse & Mfg. Co.

Edison Storage Battery Co. exhibit included a display of all battery parts by which each step in the process of manufacture of the Edison Battery was demonstrated. The car lighting cells as exhibited were of the new suspension type in which a dead air space of 2½ inches is provided between the bottom of the cell and the bottom of the plates, the purpose of this being to eliminate grounds, etc., at this point. Mr. H. G. Thompson, F. V. McGinness, and Mr. G. F. Wakeman represented the Company at the Convention.

Electric Storage Battery Co. showed their standard car lighting types of chloride accumulators and exide storage batteries. Mr. G. H. Atkins, H. E. Hunt, R. I. Baird and H. M. Beck represented the Company at the Convention.

General Electric Co., exhibited a small instrument particularly adapted for testing work, motors, mercury arc rectifiers, transformers, compression chamber lighting arresters, and new k. 20 oil switch.

Mr. J. Scribner, L. L. Parker, C. C. Douglas, C. H. Jones, J. L. Buchanan, F. Benson, A. Z. Hain, C. M. Langfeld, J. D. A. Cross represented the company at convention.

Electrical Testing Laboratories had a lantern illustrating device with a large number of slides showing views of the interior of the testing laboratories, methods of testing, etc., which were extremely itneresting and

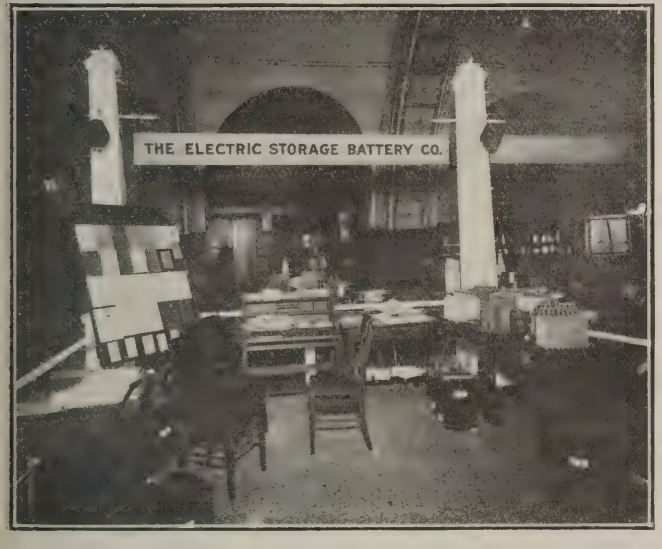


Exhibit of the Electric Storage Battery Co.

Exhibit of the General Electric Co.

instructive. A big 3000 watt, 2700 candle power tungsten lamp occasionally illuminated their booth. This is the biggest incandescent lamp ever made. Three drawn tungsten filaments are braided together and these placed on a large spider as is the standard practice in lamp manufacture. This lamp is not manufactured commercially at the present time. Mr. M. D. Macdonald and Mr. Preston S. Millar represented the company.

The Esterline Co. exhibited a new axle generator type locomotive headlight equipment which is of special interest to railway men, for it marks a new departure in the application of the axle generator systems for electric headlight service. The generator was very small and similar in construction to the magnetos manufactured by that company except that it had a differential field winding to compensate for rise or fall of train speed. The windings of this differential field are cut in or out by a D'Arsonval regulator.

The headlight exhibited was of the mirrored type, made of green opal plate glass of special composition which gives the reflected light a pecular golden glow. This is accurately ground to a parabolic surface and

Exhibit of the Edison Storage Battery Co.

mirrored on the back. Mr. Geo. Bell, sales-amanager, was in charge of the exhibit.

Flexible Steel Lacing Co. exhibited their "Alligator" fastener for various sizes of belts. A tensile machine was provided to show the strength of the fastener and various tests were made, both on fasteners and belt samples. Mr. G. E. Purple and C. W. Beach were in charge of the exhibit.

The George Cutter Co. exhibited a five light boulevard post, an entrance crook, street hoods and very narrow car lighting panels, the compactness of these panels being effected by the super-imposing the bus-bars instead of spreading them out as usual practice. They also showed an induction motor switch for automatically starting 3 phase induction motors. Mr. O. B. Duncan was in charge of the exhibit.

Gould Coupler and Storage Battery Co., exhibited their "Simplex" system including a type B. B. generator, regulator, type M lamp regulator and generator designed for ball bearings, all parts of which are made so as to interchange with those of present types.

Exhibit of the Gould Coupler Co.

They also exhibited a new vent plug made of lead, but arranged with a drip point in the center so that all condensation of escaping gases will drop back into the cell. They also exhibited a 120 ampere hour cell with pasted plates made up in into the standard compartment tanks with four cells per tray. These are designed for use in lighting cars where the service is extremely light.

A motor generator set using a standard car lighting generator in connection with a standard 300 ampere hour battery was operated through all ranges of speed, equivalent to variation of train speed from 0 to 90 miles per hour, and the current and voltage of all parts of the system was at all times indicated by miniature instruments on a small test board.

Messrs. Geo. Milne, R. N. Chamberlain, Geo. R. Berger, M. R. Shedd, Chas. O. Baker, W. T. Sherman and S. W. Cowles represented the company at convention.

Hess-Bright Mfg. Co., exhibited a large board filled with ball bearings of all sizes and capacities. A 300 lb. weight was suspended from a shaft midway between two bearings, one as ordinary babbit bearing and the other a standard Hess Bright ball bearing. A small hand crank was provided on each of the bearings, so that any visitor might turn either or both of the two bearings which carried an equal weight and compare the friction of each; needless to say there was a marked difference in favor of the ball bearing. W. L. Batt was in charge of the exihibit.

Holophane Works of the G. E. Co., exhibited some of their new semi-indirect units and also a very attractive satin finished reflector and prismatic bowl combination for station lighting. They also exhibited a new and extremely large center deck fixture with a prismatic reflector, prismatic bowl and an opal envelope of light

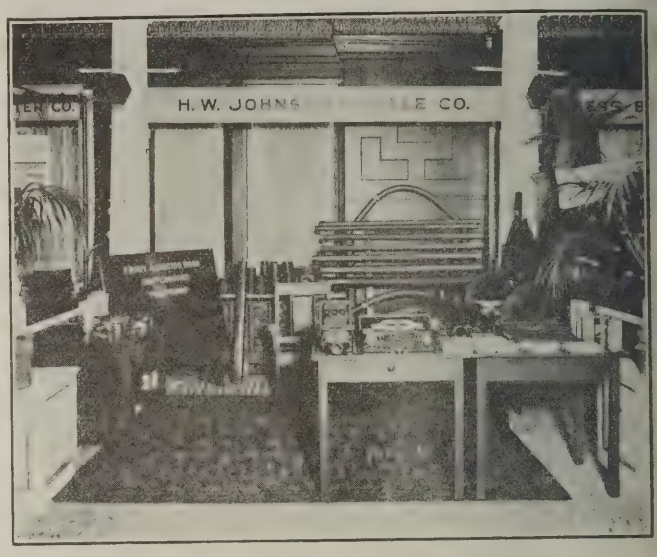


Exhibit of the H. W. Johns-Manville Co.

density, this latter installed mainly for purpose of keeping the dust off the prismatic reflector. They also exhibited their new hexagonal unit, which has proven so successful for dining car and library car lighting.

They also showed two new types of glassware: one, the white iris which in day light has a beautiful pearly appearance and at night has beautiful shaded brown decorative lines, and the other, "Calla" glass which is

Exhibit of the Kerite Ins. Wire & Cable Co.

chalk white both under day and night conditions. Both of those these types of glassware are of dense opal and very efficient.

They also exhibited all sizes of outdoor station lighting units in sizes from 25 to 250 watts. These have a prismatic reflector with a large opal envelope to keep the dust and water off the prismatic reflectors.

They also showed a complete line of aluminized and enameled reflectors and also a new vestibule type enameled reflector made of one piece of steel. This is designed to fit into the holes that accommodate the present units in the vestibules of pullmans and coaches. They also showed a complete decorative line of all artistic types of glassware. Messrs. A. J. Sweet, J. W.

Foster, and L. C. Doane, were in charge of the exhibit.

H. W. Johns Manville exhibited a full line of fuses and service boxes. They also showed their ebony asbestos board for switch boards and panels, fibre conduit, friction tape and linolite lamps. Mr. E. A. Hurlbut and L. L. Cohne were in charge of the exhibit.

Exhibit of the Main Belting Co.

J. Lang Electric Co. exhibited their new car lighting panels of very narrow and compact design, and also their automatic starting device for three phase motors. O. B. Duncan was in charge of the exhibit.

Kerite Ins. Wire & Cable Co., showed a complete line of wires and cables, both plain Kerite and armored Kerite for power, submarine and car lighting work. They also exhibited an especially flexible cable for use

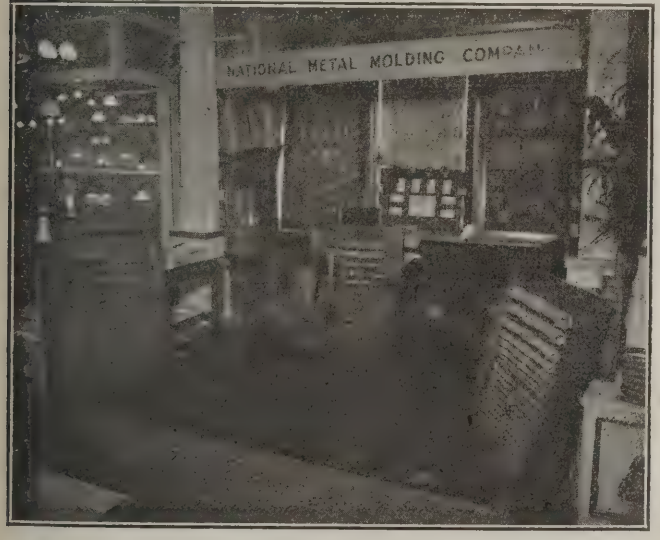


Exhibit of the National Metal Moulding Co.

on train connections. The high qualities of Kerite insulating tape were also demonstrated. Maj. Azel Ames B. L. Winchell, Jr., P. W. Miller, J. W. Young, Geo. A. Graber represented the company at convention.

Main Belting Co. exhibited their new Laviathan special car lighting belt. They had an operating exhibit of a motor driving a car lighting generator arranged so as to demonstrate the adhesive properties of the belt. They exhibited one belt that had covered 52,432 miles on a 65 ampere machine, and another that had covered 43,-710 miles on a 100 ampere safety machine. Neither belt was worn out, but were removed their respective cars for exhibit at the Convention. Mr. W. E. Fawcett was in charge of the exhibit at Convention.

National Metal Molding Co. exhibited a full line of Sherardized ridged conduit, flex-steel metalic conduit and armored cable, and flex-duct none-metalic conduit. They also exhibited a full line of National Metal Molding fittings specially designed for railway car wiring, National lock nuts, bushings and outlet and switch boxes. Mr. I. A. Bennett, C. A. Abbott, N. C. Morgan represented the company at convention.

National Elec. Lamp Association exhibited a complete line of lamps for both the standard 110 volt service and 30 and 60 volt car lighting service. C. W. Bender and J. A. Hamilton were in charge of the exhibit.

The Norma Co. exhibited their roller bearings with a small bearing to take the end thrust. This bearing has an exceedingly large carrying capacity and is to a certain degree self alligning on account of the fact that

Exhibit of the National Electric Lamp Association.

the upper race course has a slightly convex surface permitting the axis of the inner race course with the rollers to accommodate itself to any irregularities in the shaft allignment. Mr. Langnickle was in charge of the exhibit.

Oneida Steel Pulley Co. exhibited both their flanged and flangeless type Keystone R. R. pulleys. They also showed a new ratchet wrench for tightening bolts on axle pulleys where there is only a slight angle to work in. They also exhibited their standard corrugated bushing both in the long type with bushing clamps for permanent mounting on the axle and the short type for shimming up the pulley without a bushing clamp. Mr. N. G. Stark was in charge of the exhibit.

Pass & Seymour Co. showed a complete line of sockets and wiring devices and also showed their new Surlock locking device for all types of sockets which makes it impossible for the lamp to work loose or be stolen. Mr. V. R. Despard, and F. T. Haffner represented the company.

Pyle National Elec. Headlight Co. exhibited their new headlight with pilot lamp attachment for use in stations, when approaching another train and at any time the intense beam of the arc is found objectionable. The headlight case is electric welded and accordingly of strong ridgid construction. They showed their new type E. turbo generator equipment which is of low steam consumption and of simple mechanical construction. The new equipment is designed with the idea of

interchangeability of parts with old type equipment as far as possible. J. E. Kilker, H. P. Bayless, Chas. W. Dake, C. P. McGinnis, represented the company at convention.

Railway Electrical Engineer held forth in one of the booths near the entrance of the hall and conducted a general registration and information booth in addition to maintaining a department for separating certain parties from their cash to the extent of one dollar per. Geo. W. Cravans, M. K. Salem, and Edward Wray represented the company at the Convention.

Sangamo Electric Co. exhibited their new resistor type ampere hour meter mounted on a small switchboard panel with circuit breaker as furnished to the Pennsylvania Railroad Co. for axle generator systems. They also showed their variable shunt meters for straight storage work and their duplex dial meters for indicating both total charge and total discharge of an axle system. J. H. Hadde represented the company at the convention.

Safety Car Htg. & Ltg. Co. had an operating exhibit which showed the operating characteristics of their new

Exhibit of the Pyle National Headlight Co.

type "F" regulators. They also showed a new electric locomotive head-light, the big reflecting element of which was a silvered glass mirror mounted on a heavy door hinge. The headlight is designed to use an ordinary incandescent lamp, power for which is furnished by a portable storage battery mounted on the locomotive.

This company also exhibited a complete line of car lighting fixtures of all types and sizes. The company was represented at the convention by Messrs. A. C. Moore, J. G. Van Winkle, G. E. Hulse, L. Schepmoes, C. E. Miller, H. H. Halm, C. A. Pinyerd, J. H. Rodger.

S. K. F. Ball Bearing Co. had an interesting and attractive exhibit of their self alligning ball bearings of both radial and thrust types. Two bearings were mounted on a badly bent shaft which was rotated by a small motor. The two bearings, although operating under a very abnormal condition ran perfectly and demonstrated the self alligning feature of the bearing. F. H. Poor and G. B. Castino were in charge of the exhibit.

Thompson Electric Co. showed their cut-out lamp hanger for both arc lamps and tungsten units. This hanger makes it possible to lower the lamp from any high point to the ground for cleaning, etc. Mr. A. J. Thompson was in charge of the exhibit.

U. S. Light & Heating Co. exhibited their new type S-1 panel and B-1 lamp regulator for mounting inside the car. They showed their ball bearing generator designed to accommodate any of the standard type bearings. A part of the generator casing was cut away to

Exhibit of the U. S. Light & Heating Co.

show the interior construction. Their new aluminum brush holders were employed. Flexible leads inside the generator were insulated with cup type porcelain insulation. They also showed their standard car lighting batteries with parts cut away to show the plate construction. J. A. Smith, W. L. Bliss, W. A. Turbayne, W. P. Hawley, C. C. Bradford, W. F. Bauer, L. S. Cumming, Geo. Hentges, J. E. Widner, A. J. Mathews, R. S. Stunts, and T. B. H. Tower represented the company at convention.

Victor Balata & Textile Belting Co. exhibited their new "Axonelat" belt for car lighting work. They also showed the raw materials from which the belt is made, the heaviest and strongest duck employed in belting and the sheets of pure balata gum which is used to impregnate the belt and give it wearing and adhesive pro-

Exhibit of the Western Electric Co.

perties. Mr. Jos. Abt represented the company at the Convention.

Western Electric Company exhibited a complete line of Sunbeam lamps and D. & W. Fuses. They also had some railway telephones on exhibit such as are used in

railway telephone train dispatching and auxiliary train service. Messrs. Geo. H. Porter, T. F. Ryder, H. F. MacGuyer, and A. C. Keen represented the company at Convention.

Westinghouse Elec. & Mfg. Co. exhibited Westinghouse lamps and showed a case full of parts which demonstrated every step in the manufacture of the tungsten lamp, from the crude tungsten ore to the finished product. They also showed motor control panels and reversing planer motors, long burning flame arc lamps, transformers, meters, etc. B. F. Fisher, Jr., N. W. Storer, A. J. Cole, J. H. Bryan, R. E. Schaulin, L. A. S. Wood, R. E. S. Geare, A. N. Brown, W. H. Beattys, Jr., represented the company at the Convention.

Willard Storage Battery Co. The battery features of the Willard exhibit were rather small, one standard unit with various parts showing plate construction alone, were exhibited. But the social side of the Willard exhibit was the best on the floor. Luxurious deep leather cushioned chairs and sofas attracted many tired

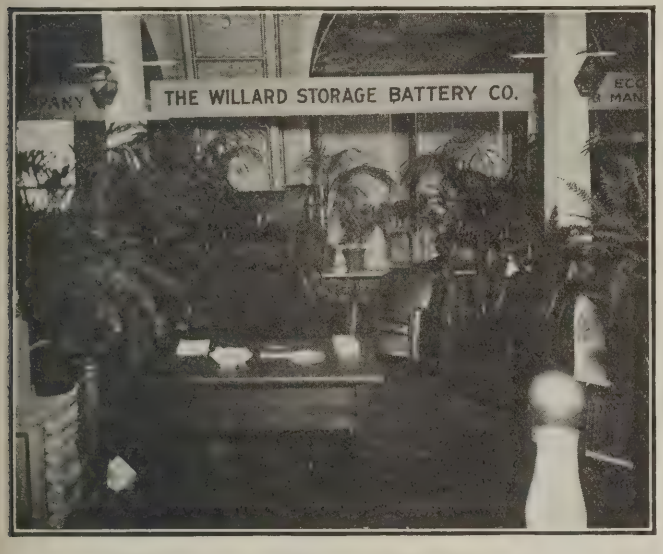


Exhibit of the Willard Storage Battery Co.

visitors to that part of the hall and the booth was a popular place. It was beautifully decorated with palms and ferns. Mr. W. E. Ballentine, F. S. Gassaway, C. A. Burrell, Lewis Sears, represented the company.

HEADLIGHT TESTS.

At a joint meeting of the Western Railway Club and the Chicago Section of the Illuminating Engineering Society, October 15th, Mr. C. M. Larson, Assistant Chicago Engineer railroad commission of Wisconsin, gave a report of a series of headlight tests made by the commission recently.

Tests were made under both standing and running conditions to determine both the ability to discern objects on the track and the ability to read signals correctly.

The tests were made using the following headlights. 1. American Headlight, 2. Pyle National, 3. Commercial Acetylene, (18" and 27") 4. 18" Bunn Safety Oil Headlight.

A man dressed in white could be discerned at 3000 ft., with an electric headlight, while a man dressed in gray or black was distinguished at 1600 and 1200 ft., respectively with the same light. The Acetylene light showed the object at 600 ft., in each case, while with the oil light the object could not be seen until within 400 ft.

As to signal tests the results of this investigation showed such a large percentage of so call "phantom lights" that the Commission considered it necessary to investigate this subject further to determine why there are not more accidents resulting from the use of electric headlights at present. In reading classification lights at 400 ft., about 82% were correctly read. It was stated in this connection, however, that standing for a considerable period of time and looking into a strong headlight is exceedingly tiring on the eyes and may have been to some extent cause of such a poor showing.

The Commission, realizing that there are over 20,000 electric headlights in use at the present time, and that if the same difficulties of incorrect reading of signals were experienced by each of these 20,000 engineers as were found in these tests, there would, without doubt be a great number of accidents every night. Accordingly, they sent representatives to personally interview a large number of railroad men including many locomotive engineers operating electric headlights.

The general opinion of practically all locomotive enggineers interviewed was that if there are any disadvantages of the high power light, these are more than overcome by the many good points in favor of the electric headlight. These engineers stated that they were able to distinguish the blades of a semaphore and be governed accordingly; and though they admitted seeing flashes of phantom lights at times they were able to recognize them as such.

The observers of these tests were for the most part railroad men including many locomotive engineers, but attention should be called to the fact however, that they were not men having had experience with use of an electric headlight, as they were representatives of the Chicago and Northwestern, and the Chicago, Milwaukee and St. Paul railroads.

According to the results of these tests, the high power headlight seemed to be too strong, whereas the oil lamp was too weak. It was unfortunate in this connection that some of the electric headlights of lesser candle power were not also tested. This would include some of the tungsten lamp equipments, also the Moon headlight which projects its beam of light by means of the arc. When this light is properly focused it is impossible for the engineer of an opposing engine to get direct rays from the arc itself. A discussion of the paper by various railroad, university and supply men brought out some very interesting points.

Prof. C. F. Harding of Purdue University said that there is a demand for the more powerful headlight, but as this appears to obliterate signals it seems logical to increase the intensity of the signal lights correspondingly. He pointed out however that it contains many disadvantages which railroad men would appreciate. He also stated that it might also be possible to reduce the beam down to a nearly cylindrical one instead of a diverging beam as now used. He thought, however, that locomotive engineers would object to that because they wished to see surrounding objects to some extent which act as markers in maintaining schedule time. He also pointed out that it might be possible to increase the intensity of the electric headlight until it became possible to use the semaphore position signals entirely instead of light signals. He pointed out that the difficulty in phantom lights is largely due to the fact that the headlight, the signal, and the engineer are somewhat near the same level. He suggested that if signal lamps were placed lower the phantom light would be greatly reduced.

Mr. Geo. L. Wilson gave an interesting talk on the acetylene light and pointed out that while an acetylene headlight cost but $65.00 initially, it does not cost any more to operate than an ordinary oil headlight.

Mr. H. T. Bentley, Asst. Supt. Motive Power, C. & N. W. Ry., pointed out that they used banjo type signals

in which there were no semaphore position arms employed. He stated that if they had believed that the electric headlight would insure greater safety to the traveling public it would have been installed on the North-Western long ago.

Mr. J. F. DeVoy, Asst. Supt. Motive Power, C. M. & St. P., stated that he has had orders for some time past, that if he thought the electric headlight was the proper thing it would be adopted by that road, but up to the present time, however, they have not considered it advisable. He stated that the large amount of switching in Chicago and Milwaukee terminals makes this impractical.

Mr. John Meeks, a locomotive engineer of the Soo Line, who uses an electric headlight, stated that since this investigation had been begun he paid particular attention to see if at any time his electric headlight would change the color of signals, but up to the present time he had never been deceived in the indication of a signal. He said that it was true that he occasionally got flashes of light back from the surface roundels, but the experienced engineer easily distinguishes them from the true signal light. He said that his electric headlight had saved the lives of two men who were on a trestle, and if it had not been for the electric headlight showing up these men at a distance of over a 1,000 ft. they would undoubtedly have been killed.

As to classification lights he said they always blow a whistle signal in addition to the lights and always receive an answer from the waiting train or stop to find out why answer was not given.

Mr. J. G. D. Mack, Prof. of Mech. Engr. University of Wisconsin, called attention to the fact that an experienced blacksmith can tell the color of a piece of steel in the fire, while the ordinary observer is blinded by the glow of the coals and usually can tell nothing about it. He stated that practically all the observers in these tests were men who have had no experience with electric headlights and said that this might explain the high percentage of false signals observed.

Numerous other gentlemen presented arguments pro and con, and a vote of thanks was finally extended by the Club to Mr. Larson and other members of the Commission.

Light: Its Use and Misuse.

A Primer on "Illumination" Prepared by the Illuminating Engineering Society.

It is the purpose of this publication to assist the user in making artificial light effective, whether the light be produced by oil, gas, electricity or otherwise.

By proper use you can get good illumination from any of these sources, but by misuse you are likely to get lighting that is bad, costly, and even dangerous to the eyesight.

ILLUMINATION AND COMFORTABLE VISION.

To see easily and comfortably you must select the lamps, fixtures and globes and arrange the lights so as to best suit the particular conditions which have to be met, but certain principles which must always be followed may safely be laid down.

Don't Judge Illumination by the Brightness of the Lamps.

Judge the light you are getting by the way it helps you to see. Do not think because a lamp looks glaring and brilliant that is giving you good light. It may be merely giving you too much light in the wrong place. On the other hand, a well shaded table lamp may look dim because it is well shaded, and still be giving first-class light for working purposes.

You must get enough light to see by, and as you see things chiefly by the light which they reflect, it is evident that dark colored objects which reflect light badly require more light than do light colored objects to see them comfortably. That which is quite sufficient for sewing on white cloth, for example, will not do at all for working on black cloth.

Don't Work in a Flickering Light.

See that your light is steady. If you leave a dark room and go into bright sunshine the sensation is unpleasant to the eye; if you use a light that flickers, you get this same unpleasant sensation, perhaps as rapidly as twenty times a minute. Furthermore, the eye endeavors to adjust itself to suit the light; if the light flickers it keeps the iris of the eye "see-sawing," as it were, and the muscle that governs it gets tired and reacts on the nerves to cause discomfort and pain. Reading in railway trains causes similar strain; the eye muscles get tired in trying to follow the shaking page, and are likely to provoke a headache.

Don't Expose the Eyes to an Unshaded Light.

It is bad to have an unshaded brilliant light glaring into the eyes, for it throws hard labor upon them in an effort at adjustment. This applies even to common electric, gas, or oil lamps. While artificial light may be made a good substitute for daylight, you have constantly to beware lest rays that are too bright, either from the lamps or from their reflections, hurt the eyes. You can get reflections, so bright as to be harmful, from polished metal or glass, from bright varnished surfaces or even from glossy white paper upon which the light falls.

A bright light fairly in the field of view means a very brilliant light on the retina, producing fatigue. Everyone knows the blinding sensation of looking at the sun with its sequence of dazzling colored images Babies are here common sufferers when careless mothers or nurses allow them to lie in their carriges with eyes exposed to the unclouded sun. Bright artificial lights. in a less degree, do the same thing to all of us. And when you get a bright light in the field of view, the pupil tries to shunt it out; in so doing it renders less bright things all but invisible. Thus it is hard to see things which are nearly in line with a brilliant light, as you often find in facing an automobile headlight, or looking into a show window.

A Couple of Simple Experiments.

Place an unshaded lamp in front of a picture on the wall and then stand back a few feet and note how much of the picture you can see clearly. Then hold a book or paper at arm's length so as just to cover the bright light and note the way in which the picture clears up. Again, put an unshaded lamp about a foot in front of your eyes and try to read a newspaper just beyond it. Then shade your eyes from the lamp and try it again. You will soon find out in this way that lamps can be so placed that they will be a hindrance rather than a help in seeing.

Best Direction of Light.

From time immemorial mankind has received its light mostly from the sky. Consequently the part of the retina on which the light from above chiefly falls is pretty well

used to it, while bright light from below, falling on the part of the retina which commonly gets light only from grass or dark pavements, may be very irritating and unpleasant. Thus the glare from snow and sand is not only disagreeable on account of its intensity but because of the unusual direction from which it comes. Just so with a brilliant beam reflected from glossy paper on which you are writing. Its rays strike you from an unusual direction and are harmful for that reason. Other smooth and shiny surfaces deliver an equally hurtful assault on that sensitive and much abused organ,—the eye.

Don't Read Facing the Light.

It is best to have the light come from above and somewhat sidewise, as it commonly does in nature, so that you will not get a brilliant reflection or glare from what you are trying to see. In reading and writing it is better to have the light come from the left, to avoid getting a shadow of the hand that holds the book or pen. Let the lamp be just far enough behind to keep direct reflections from the paper out of the eyes. But what has been said of reflections from paper applies with even more force to the case of polished metals, or the like, over which one is busy. Individual lights placed close over the work are very likely to produce these troublesome direct reflections and consequently such lights are falling into disuse. In an interior otherwise dark, their use is open to the further objection of giving bright spots of light and so producing too violent contrasts of light and shade.

Don't Use a Bright Light Against a Dark Background.

Almost any light will glare unpleasantly if the surroundings are thoroughly dark. As an extreme illustration, the light from a big arc lamp hung close to the sidewalk may be very annoying at night, but by day you would hardly notice it. Just so a bright lamp against a dark background may be annoying, while against a light background it would not be so unpleasant.

LAMPS, FIXTURES, GLOBES, REFLECTORS.

One may choose to-day among lights of many kinds. There are at hand candles, oil lamps, open flame gas jets, upright and inverted mantle gas lamps, electric incandescent lamps of carbon and of tungsten, electric arcs of half a dozen varieties, besides mercury-vapor tubes, acetylene lamps, as used on motor-cars, and so on through a long list.

What do you wish to use a light for? To read or write by, to bring into view the working parts of a machine, to match colors, to display goods, or pictures; or merely to make a pathway safe and plain? Each case is to be studied by itself, and the effect is to be accomplished by such lamps, globes and reflectors as, properly disposed, will insure ample lighting without glare, and yet with strict economy.

However good and suitable the lamp, it will be put at a disadvantage unless the lighting fixture which carries it is designed to hold the lamp in the right position to enable one to best utilize the light which comes from it. Prettiness in a fixture is well enough; but let the fixture be serviceable first; then it may be also as pretty as you please. But don't buy prettiness if it makes war on good service.

Daylight is naturally well diffused; but artificial light, poured out as it is from mere points, or narrow surfaces, needs to be tempered or softened by shades. And it sometimes further requires to be directed upon a desk or table or other object. In some cases it is better to adopt indirect methods, and throw the beams of a lamp upon a ceiling whence the rays are scattered. For every particular need there is ample provision amid the abounding lamps, globes and reflectors of present day designers.

Arranging Lights.

Two methods are usual in arranging lamps: first, to secure general illumination by so placing the lamps that you may see with comfort anywhere in a room; second, in cases where a bright light is not necessary throughout a room illumination can be planned, placing the lights where they will be most used, always remembering that it will not do to localize light too much, since you need for comfortable seeing a fair quantity of light broadly distributed.

(To Be Continued.)

Lesson No. 10.

Axle Lighting

We realize that the troubles of the axle light man and those of the electrician in charge of headend system are so different that as a general thing the axle light man is not much concerned about what the headend man is up against and the headend man don't care to worry about the things that make the axle light man scratch his head.

Maybe some of the headend boys have felt that the last two lessons were a little out of their line. That is probably true, but from now on we are going to carry two separate departments in this course, one intended for the axle light man, and the other for the headend electrician.

The man who has been in the axle light game since the early days of the art will realize better than anybody else what a great number of different types of machines and regulators have been brought out. The younger man, the fellow who has come into the game during the past two or three years will probably not even make a bluff at fully understanding all of the equipments operated. Maybe he gets a pretty good idea of one or two of the types most generally used, and with a superficial knowledge of the others lets it go at that; but it is the purpose of these lessons to tell all of the boys about all of the different kinds of car lighting devices.

There are a good many old type "A" Consolidateds still in service, so we are going to start with that equipment this month and take up each of the various types, each in the order that they were brought out, ending up with the newest voltage-current type of regulators.

If there are any points we don't make plain, we hope some of you boys will call us. We will be glad to do

our best at answering any of the questions put up to us.

CONSOLIDATED TYPE "A" EQUIPMENT.

If you will refer to our September lesson, you will see that we there divided all axle systems in the following classes.

1. Belt slip type. (Stone system)
2. Armature reaction type (Rosenberg generator used in Europe).
3. Differential series field.
4. Variable resistance in shunt field. (This includes all of the equipment used in U. S. today, and they operate on either of the following three principles:

(a) Generator current control, (b) Battery current control, (c) Combination generator current and voltage control.

The type "A" Consolidated is of the constant generator current control class, as the regulator operates so as to maintain the generator current at a certain number of amperes regardless of train speed.

The generator is of bipolar, simple shunt wound type, and is provided with self-oiling bearings. The generator case is of a square corner, box type with suitable hand holes for inspection and repair. The bottom of the generator is pivoted on a rocker pin which is supported by a cradle as shown. A single tension spring is applied for maintaining proper speed tension. There is a heavy iron bar fastened to the bottom of the generator which engages a vertical tension spring. Tightening the spring presses down on the bar and causes the generator to rock slightly away from the axle, which tightens the belt. It should be noted that the generator does not slide at all in the cradle but merely rocks on this rocker pin.

The field pieces of the generator are made up of laminated sheet iron, but there are a few sheets of hard steel inserted so that there will always be some magnetism in the generator field even when the car is at rest. This will then cause the generator to always build up in the right direction. If these sheets of hard steel were not used the magnetism of the generator might disappear entirely when the car stopped. In fact, there might be a slight magnetism in the wrong direction due to the earth's magnetism for some local cause such as being near a power plant, and when the car started on its run and build up for the first time, the voltage might be in the wrong direction; then when the automatic switch closed both generator and storage battery would short circuit right through each other.

The pole changer is of the worm geared type. A small steel worm is cut on the end of th generator shaft, and this engages the brass gear on a shaft mounted crosswise. On this small shaft there is also mounted a special cam device which is so designed that if the car is run in the reverse direction it will force the cam follower into another groove. This throws over a switch which reverses the connections of the generator covering only a period of about 15 seconds, and although the worm gear operates all the time the generator is running there is very little wear as there is no power transmitted. This type pole changer is still used today on new type generators manufactured by this Company.

Automatic Switch.

When the train pulls out of the terminal the first thing that happens is that the pole changer throws over and gets the generator in line to develop the correct polarity, then as the speed increased the voltage gradually raises

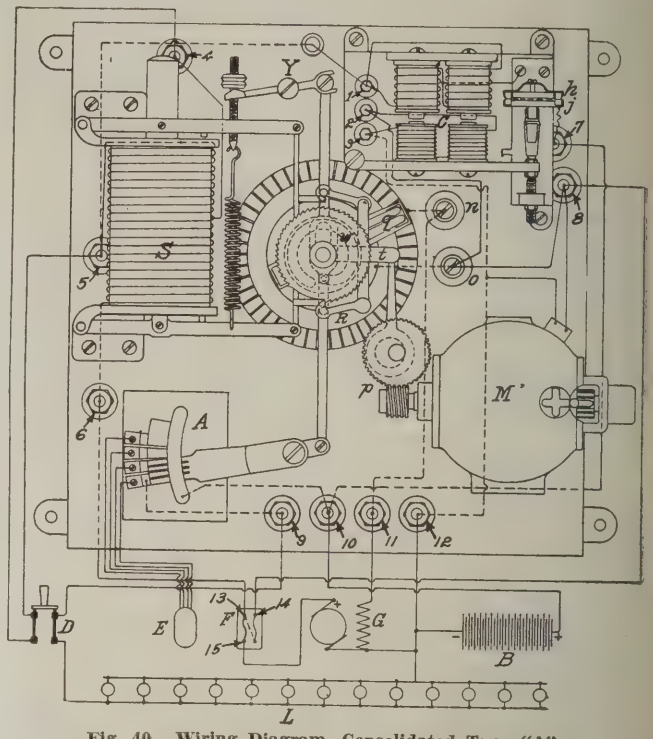


Fig. 40. Wiring Diagram, Consolidated Type "A".

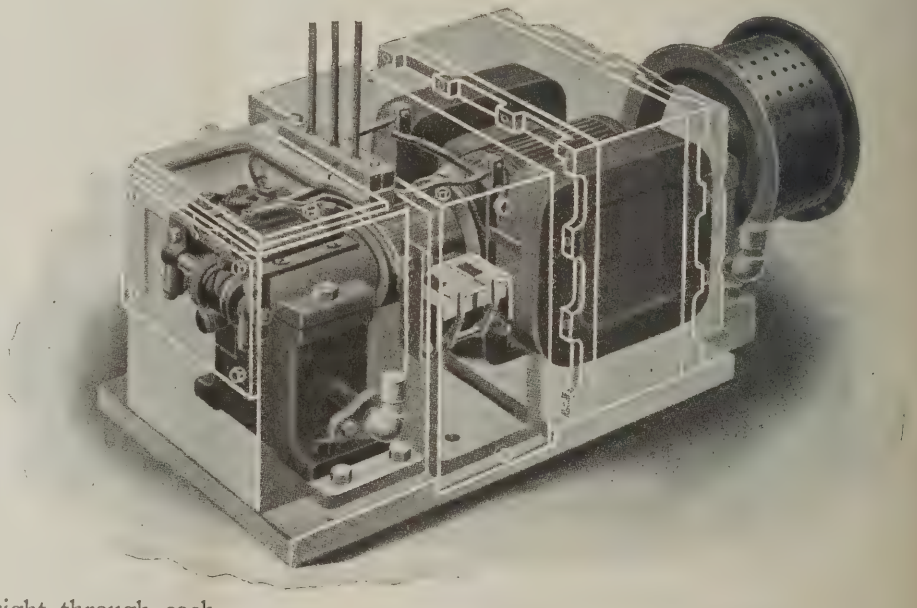


Fig. 41. Consolidated Type "A" Generator.

until the train gets up to a speed of about 15 miles per hour. The generator is then developing about 30 volts on a 30 volt system, and this is sufficient to generate enough magnetism in the shunt coils of the automatic switch (See Fig. 40) to cause them to pull up and close the switch at "H."

It should be noted that the automatic switch has four separate coils, two shunt coils which are wound with fine wire and connected permanently across the generator terminals, and the two series coils wound with heavy wire through which the total generator current passes.

This lifts up when closing the switch and drops down when opening. An adjustable lock nut makes it possible to raise or lower this switch arm carrying the shunt coil. If it is set higher so as to give a smaller air gap between the two poles the switch will close at a lower voltage, but if the lock-nut is adjusted so as to lower this arm and open the air gap wider, it will require a higher generator voltage to lift the shunt coils and close the automatic switch.

After the generator reaches a speed of 15 miles, the automatic switch closes and connects the generator in parallel with the battery across the lamp circuit.

If the battery voltage happens to be slightly lower than the voltage of the generator as it cuts in, the generator will assume all of the lamp load and possibly charge the battery slightly. This will cause a heavy current to flow through the series coils of the auto switch which are wound so that when the current flows in a charging direction the magnetism of these coils will add to the magnetism of the shunt coils and pull the switch up solidly.

If the battery voltage happens to be equal to the generator voltage when the automatic switch closes, there may be very little or no current flow from the generator

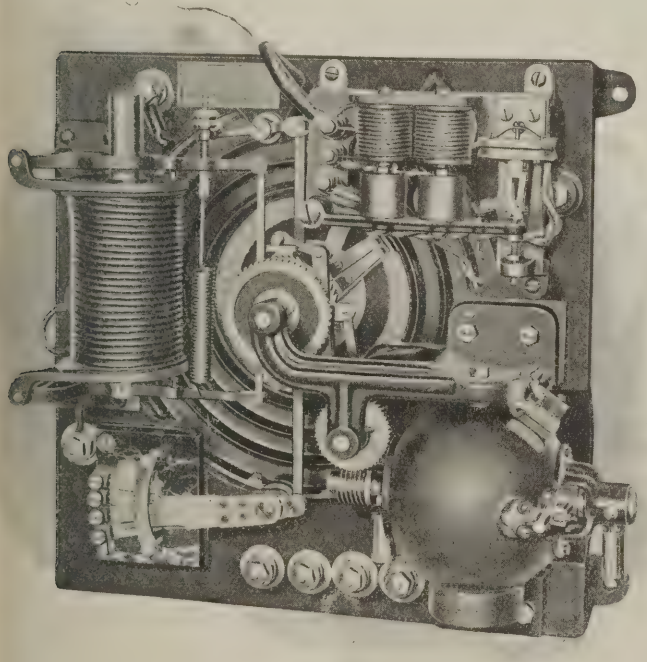


Fig. 42. Regulating Panel and Automatic Switch.

at first, but as the train speed raises a little higher, the generator voltage will increase two or three volts higher than the battery voltage, and it will assume the entire lamp load and possibly charge the battery.

When the train slows up for a stop and the train speed falls again to the cutting in speed of 15 miles per hour, the generator voltage will be just about equal to the battery voltage, and gradually shifts the lamp load over to the battery. As the speed falls a little lower, the generator voltage will fall below that of the battery and the battery will then tend to motor the generaor causing a curren to flow in the reverse direction; but this reversed current flows through the series coils of the automatic switch and develops a reversed magnetism in these coils which neutralizes the magnetism of the shunt coils and causes the switch to drop open.

If it were not for this action of the reversed magnetism in the series coils, the shunt coils might cause the automatic switch to stick shut when the train slowed down, causing a very serious discharge of the battery through the generator.

It often occurs that on long divisions when the train is sometimes running for hours at a speed of about 15 miles the generator may not be able to charge the batteries at all although the automatic switch may be closed.

The Generator Regulator.

The regulator as shown in Fig. 40-42 operates so as to deliver constant generator current at all times that the train is cutting in speed with the automatic switch. The total generator current passes through the heavy winding of the regulator coil "S." Inside this regulating coil is an iron plunger which projects 3 or 4 inches above the top of the coil, and is held up by the pull of an adjustable spring. A small motor "M" operates all the time the automatic switch is closed and through a worm gear drive "P" causes the two little dogs "R" to rock back and forth continually. A field resistance with commutating segments is mounted on the board and in place of the usual hand adjusting wheel there are mounted ratchet-wheels. One set to turn the resistance arm in the right hand direction, and the other in the left hand direction. Each of the two little dogs are adjusted to operate one of these ratchet-wheels, but they are normally kept from engaging the ratchet wheels by means of the two guides.

The magnetism generated by the current flowing through the regulating coil "S" pulls the plunger downward but this is balanced by the upward pull of an adjustable spring. If the generator current increases above normal value however, the magnetic pull downward on the plunger overcomes the pull of the spring and lowering the guides permits one dog to engage its ratchet-wheel and slowly pull the resistance arm "Q," cutting resistance in to the generator field circuit. This of course lowers the generator voltage until the current generated falls to normal value, when the spring again balances the magnetic pull and raises the guide and ratchet dog so as to stop further motion of the resistance arm. If the speed falls and the generator current through the coil "S" is reduced the reverse operation occurs, the lower dog engages that ratchet wheel and cuts out generator field resistance raising the generator voltage to normal field value.

Lamp Regulator.

The lamp regulator of this equipment is simply a fixed resistance which is inserted by a cam device when the first few segments of the generator field resistance are cut in.

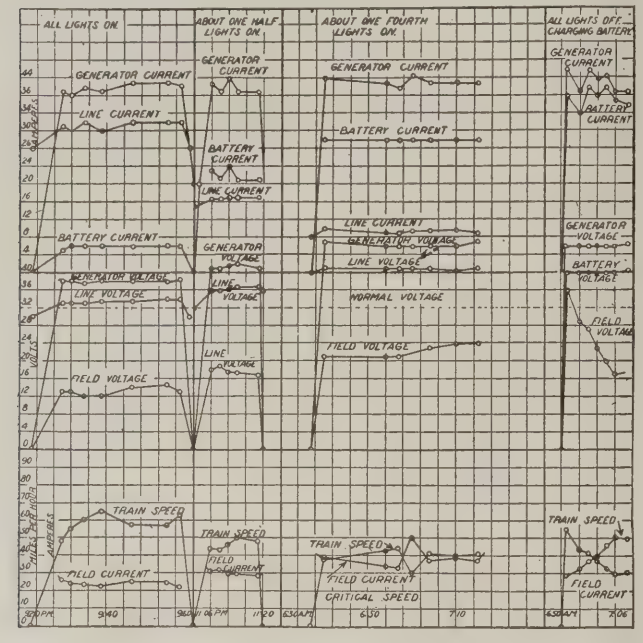
Principles of Operation.

The principles of operating this equipment can best be understood by refering to the curves of an actual test conducted some time ago by the writer.

It should be noticed that these curves show portions of an all night run giving one hour's operation in the evening with all lights on, ½ hour operation at about 11 P. M., with half the lights on, an early morning run for 2 hours with about ¼ of the lights on, and later a half hour run with no lights on. The first thing I wish to call your attention to is the fact that the generator current remains practically constant at 42 amperes regardless of what the train speed is or how many lamps are turned on. It should be noted that when the lamp current or line current, as it is labeled, is reduced from an average of 32 amperes to 16 amperes, the battery current increases from 6 amperes to 22 amperes. As the lamps are turned off the current which those lamps took must then go into the battery.,,

It should also be noticed that the generator voltage at the beginning of the test averages about 38 volts. This later arose to 42 volts, and in the morning was operating at 46 volts. This shows the rise in battery charging voltage.

As a matter of fact, the average battery charge was 197 ampere hours, while there was only an average dis-



charge of 50 ampere hours. Without doubt the battery was fully charged by 2 A. M., and from that time until 7.10 A. M., when the lights were cut off the battery was overcharging at the rate of 28 amperes.

This clearly demonstrates that the regulator of this equipment was set too high.

These curves also show that the "line" or lamp voltage raises with the generator voltage. That is, it starts at 32 volts and gradually raises during the night from 33 volts to 43 volts in the early morning. This plainly shows up the faults of the old fixed resistance type lamp regulator. As the number of lamps were decreased in the middle of the night, the voltage drop consumed in the lamp resistance would decrease proportionately so that when the battery became charged this high overcharging voltage would come almost directly on the night lamp circuit. These lamps were very badly blackened. It must be remembered however, that this was in the days before our present lamp regulators were on the market; but it shows the way that an axle equipment without a special lamp regulator strains the lamps.

It should also be noticed that the higher the train speed the less field current required. When the train averaged around 60 miles per hour the field current was approximately 2:5 amperes, while a train speed of 40 miles per hour the field current increased to about 4 amperes; while with a train speed of 30 miles per hour the field current was 5½ amperes.

Important Results of Test.

Chicago to Kansas City.

Total time of trip	14 hrs. 10 min.
Total time of generator operating	11 hrs. 35 min.
Total time Generator, not operating	2 hrs. 35 min.
Total time Stops	1 hr. 22 min.
Total time Generator running dead	1 hr. 13 min.
Total time Lights on Batteries	2 hrs. 35 min.
Total Generator Output	19.6 k.w. hr.
Total Lamp Consumption	8.38 k.w. hr.
Total Battery Charge	208. amp. hrs.
Total Battery Discharge	49 amp. hrs.

Kansas City to Chicago.

Total time of trip	13 hrs. 42 min.
Total time Generator operating	10 hrs. 55 min.
Total time Generator not operating	2 hrs. 47 min.
Total time of stops	1 hr. 24 min.
Total time Generator running dead	1 hr. 23 min.
Total time Lights on Batteries	2 hrs. 47 min.
Total Generator Output	19.2 k.w. hr.
Total Lamp Consumption	7.28 k.w. hr.
Total Battery Charge	185 amp. hrs.
Total Battery Discharge	50 amp. hrs.

Above readings are corrected for loss in test connections. Average generator is 80 per cent.

Assuming a battery efficiency of 50 per cent. to cover battery losses and emergencies, the average ampere discharge per trip of 50 ampere hours would require an average charge of 100 ampere hours. As a matter of fact however, the battery was receiving an average of 197 ampere hours which meant a destructive overcharge of 97 ampere hours every night. As the generator operated approximately 11 hours, this meant that the generator was set 9 amperes too high. It should have been set for 33 amperes instead of 42.

Practical Stunts.

To the Editor:

As an example of one of the dam-fool connections that a fellow can make if he isn't careful; the writer accidentally connected the wire that should go from the shunt coil terminal of the automatic switch to the field side of the resistance unit of an old type "A" Consolidated instead of connecting it direct to the generator lead as customary. The machine would pick up O. K., and the automatic switch would go in properly, in fact, it would work fine until the train got up to a speed of about 40 miles, when the automatic switch would drop out and the field regulator work back to the dead position. When the field resistance was about all cut out, however, the automatic switch would go back in again with a bang and for a minute or so the equipment would operate O. K., when the automatic switch would again drop out, etc.

One man who should have known better got into this trouble and was sorely puzzled at the freaky action of the regulator and automatic switch, and came near dismantling the regulator completely, when all that was required was changing one connection.

It is a good scheme to stop and think at least once before using tools.

Annonymous.

To the Editor:—

In your October issue I read with a great deal of interest the answer you gave to my questions of recent date. I do not think, however, that you have made my point entirely clear in the case of buckled or shorted plates.

When this takes place we all know that the tree of lead, as you call it, forms and is very small at first, but if allowed to remain increases to a large size. This naturally discharges that particular cell.

As I understand it a cell discharged normally, bringing the electrolyte down with it in proportion to the discharge, can be brought back to normal by charging. Where a cell is discharged abnormally, however, as mentioned above, is there any chemical action takes place that kills the acid, bringing it down to 1150 specific gravity. Is the electrolyte dead from this chemical action?

Now then, suppose I have such a case and I remove

the shorts from the elements, what would you say about using this same electrolyte over again? Can it be brought back to 1220 specific gravity by charging? What we have usually done is to throw the electrolyte away and supply new electrolyte of 1220 specific gravity, so as to give the cell a new start.—Harvey Davis.

Answer. Whenever a cell discharges there is a chemical action goes on, the lead and lead oxide in the plates turning to a soluble lead sulphate. If the cells are allowed to stand very long the insoluble lead sulphate, may change to insoluble white lead sulphate which is very hard to break up, the plates are then said to be "sulphated." As you say, when a cell discharges it reduces the gravity of the electrolyte, but this is brought back to normal by charging the battery. The same is true of the white sulphate. You can bring the cell back to normal gravity if you charge it long enough so as to break up the sulphate compound into active material and acid which goes back into the electrolyte.

As to giving the cell a "new start" by throwing away the old electrolyte of low gravity and adding new of 1220 gravity, I would say that this is very bad practice, for if your plates are badly sulphated the first thing to do is to break up that sulphate and get the acid out of the plates back into the electrolyte by charging. If you add stronger acid and then put the equipment in service it will probably go from bad to worse. If even though it is fully charged on the road the acid held in the plates in the form of white sulphate will increase the strength of the electrolyte to 1230 or possibly 1235, and this is mighty bad practice. The plates are much more apt to sulphate where acid as strong as this is used. —Editor.

Head End System.

Most headend trains are now equipped with some kind of a storage battery auxiliary to furnish light at division points or any other time when there is no available steam to drive the turbine. These batteries are usually charged on the road by the train lighting set.

We all know that it takes a much higher voltage to charge a storage battery than the battery will give on discharge. In other words, if you have a 64 volt system it will take approximately 80 volts *at the batteries* to fully charge them. This, of course, is altogether too high for the lamps, so there must be some provision made for charging the battery without injuring the lamps.

There are four different ways of doing this.

1. Batteries and lamps on separate lines with an adjustable hand resistance in lamp circuit. (This is used on the C. M. & St. P. Ry.)
2. Small battery in every car partially charged on the road with full charge at terminals. (Nor. Pac. Ry.)
3. Full size battery on baggage car, diner and observation car, charged by cutting the battery in two parts and placing the two halves in parallel across the train line with resistance. (Harriman Lines.)
4. Individual lamp regulator on every car. The generator can then be raised to full charging voltage as desired. (B. & O.)

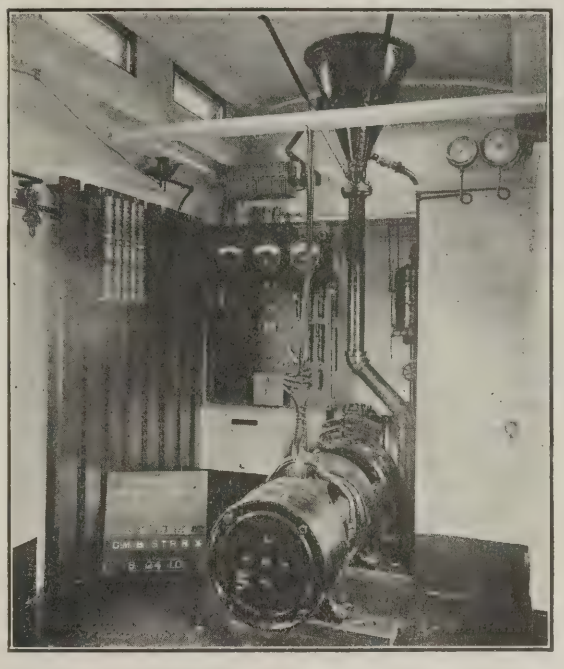


Fig. 45. 20 Kilowatt Turbo Generator In Baggage Car.

We are going to take these different systems up one by one and study each one up pretty carefully.

Lamps and Batteries on Separate Circuits.

C. M. & St. P. Ry.

The three wire train line is divided so as to give two separate circuits, one carrying the batteries, and the other carrying the lamps. This is effected by pulling down the loop at the rear of the train and throwing a switch in the baggage car which places the lamps on one circuit and the batteries on another. By inserting this extra loop in the forward end of the train and open-

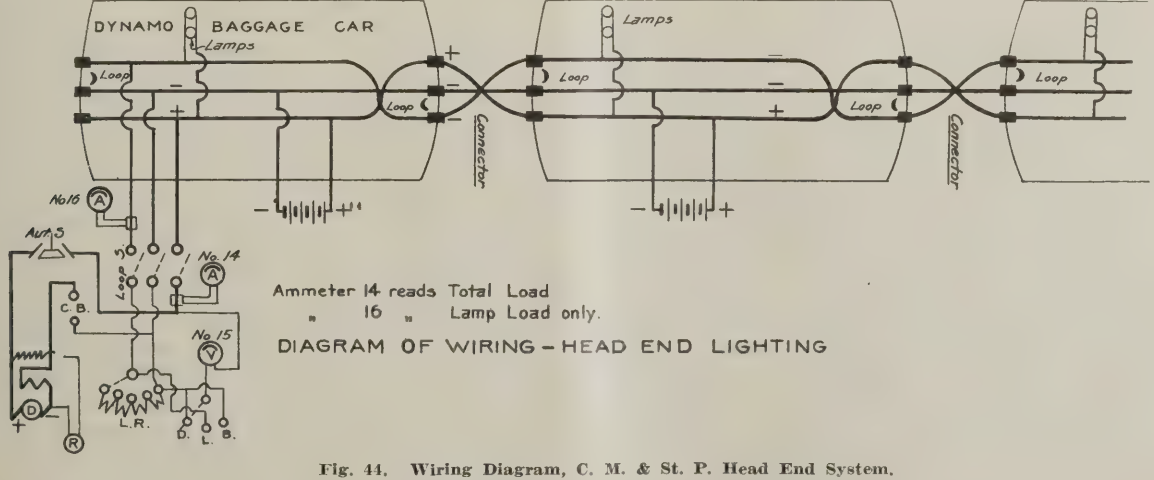


Fig. 44. Wiring Diagram, C. M. & St. P. Head End System.

ing the loop in the rear car, the train wiring is changed from the regular 2-wire equi-potential system as ordinarily operated, to two separate 2-wire systems, having a common conductor. In this particular train they use the positive of the 3-wire system for the common conductor.

The storage batteries are connected between this common positive and what is normally the generator negative, the center wire of the train connector, while the lamps are placed between the two outer wires of the train line as is common practice in this service.

A variable lamp resistance is inserted in the lamp circuit by which the train electrician may maintain the lamp voltage constant while the generator voltage may vary to any desired value in charging the storage batteries.

The operation of the equipment is as follows:

Leaving Chicago at 5:00 P. M. all lamps in the seven cars burning. The dynamo voltage is maintained at 70 volts and the lamp voltage at 65. The train line wiring is connected as in the ordinary equi-potential 3-wire system. The generator load at this time is about 110 amperes. At 11:00 P. M., when the lamp load falls to 40 amperes, the attendant throws the loop switch in the baggage car and then goes to the rear of the train and opens the rear loop. Returning to the baggage car he raises the generator voltage until the current flow of 120 amperes is obtained. Simultaneously the variable lamp resistance is inserted in the lamp circuit maintaining the lamp voltage at normal value.

Inasmuch as the lamp current at this time is approximately 40 amperes this generator current of 120 amperes provides approximately 26 amperes to each of the three batteries. As the charging proceeds the dynamo voltage is maintained constant at 78 volts, the battery current falling off as the charge progresses.

Batteries are tested for gravity both at Kansas City and Chicago, and if found low instructions are given to correct same by heavier charge next trip.

A slight change in the equipment is contemplated which will materially improve its operation in that an automatic loop switch in the rear of the car will be installed which will automatically close when the generator becomes inoperative, thereby providing two paths for the discharge flow of the battery current: one through the forward train loop and one through the rear. This will serve very materially in maintaining more constant lamp voltage and accordingly better operation of equipment.

It might occur to some that in operating the lamps on a 2-wire system the lamp voltage would fall off considerably at the rear of the train. However, a special test in this regard has been made and was found that the actual difference in the voltage between that in the baggage car and observation car was only two volts, and this occuring in the middle of the night, when a slight variation in lamp voltage is not so noticeable.

Similarly it might appear that there would be a similar objection in regard to the charging of the batteries, in that the batteries in the forward part of the train would receive a higher charging voltage than those in the rear. This, while theoretically true, is of such a small value and the condition of operation of the equipment so variable that this can practically be disregarded entirely.

A voltage test on the battery charging line failed to indicate any appreciable difference in voltage at the three battery terminals, this difference being less than 1 volt. However, this is hardly a fair criterion in this regard, inasmuch as all three of the batteries were located in adjacent cars at the rear of this train. A greater variation in battery terminal voltage would of course be experienced when the batteries are located at opposite ends of the train.

This difference in final charging voltage required by any two different batteries, however, will vary considerably and accordingly the objection to the operation of this equipment on the grounds of non-uniformity of battery voltage may be more imaginary than real.

(To be Continued.)

United States Postal Car Illumination

A talk by ARTHUR J. SWEET before Convention *A.* R. E. E.

In addressing myself to my subject, I shall for the moment assume the part of a purist in the use of English and say that while the committee have assigned me to speak on the subject of "United States Postal Car Lighting," I shall speak on the subject of "United States Postal Car *Illumination.*" Strictly speaking, the science of lighting begins with the generation of the electrical energy or of the gas and ends with the production of light. The science of illumination, on the other hand, begins with the production of light and ends in the satisfactory achievement of that sensation we call vision. In the field of lighting I should speak before you with a good deal of diffidence, for I have only a good general knowledge of the problems of that field and of the considerations upon which their solution depends. In the field of illumination, however, and particularly in the field of postal car illumination, I can address you with a good deal of confidence; for it has been my opportunity and privilege to study with abundant resources at my disposal, not only the purely technical and scientific but the practical and commercial aspects of the problems in this field.

The subject of postal car illumination is one which which by its definiteness, may well delight the heart of the true engineer. Barring one or two questions centreing around the matter of maintenance, there are no important problems in postal car illumination regarding the solution of which a difference of opinion can legitimately exist among engineers, once the fact data on the subject is presented for consideration.

The major fundamental requirements of postal car illumination are two. First and most important, the illumination must be of a character to permit the unusually severe visual work of the postal service to be performed with the very minimum eye fatigue and resultant eye strain. Second, the efficiency at which the illumination is produced must be the very highest consistent with the sufficiently adequate meeting of the requirement just stated above; for the demands upon the battery and gas supply are very severe, both in the matter of heavy load and long hours, while the importance of reducing failure to as absolute minimum is greatly increased.

There are other important though unquestionably minor considerations such as the desireability of an equipment involving minimum maintenance attention;

of an equipment involving minimum cost of initial installation; of an equipment involving minimum breakage with resultant maintenance cost. But these latter considerations cannot, under good engineering practice, be permitted to interfere with the attainment of the two major requirements expressed above. The question of artistic effect, a question at the present time unduly at the mercy of individual taste and whim, fortunately does not in the least enter into the problems of postal car illumination.

As engineers facing the problems of postal car illumination, we must, in view of the above considerations, first address ourselves to the question as to what conditions of installation will permit the eye to operate at highest efficiency, and with minimum fatigue after long-continued periods of work. This initial question splits itself into four separate and largely indendent problems,—the avoidance of objectionable shadows, the avoidance of excessive light in the eye, the avoidance of specular reflection from the mail matter, as sorted and the provision for an adequate but not too high intensity of illumination. Let us consider each of these problems.

In all classes of service, postal, office, or any other, the avoidance of objectionable shadows depends, in the case of any direct lighting system, upon the proper placement of the light units and not upon the character of the light unit or reflector.

The standardization of the construction of the U. S. postal car makes the determination of the best location of light units in order to avoid objectionable shadows a particularly easy problem. In the sack rack portion of the car, we must avoid any shadows on the labels of the rear sacks, cast by the projecting paper boxes above. This at once determines that we must place the units on the centre line of the car, as otherwise we would have to drop the units too low in order to a shadow on the sack labels. It is impossible to entirely avoid an objectionable shadow, cast by the body of the postal clerk, in all positions in which he may place himself in the course of his work. But since the clerk stands just back of the centre line of the car, the placement of the units on the centre line minimizes to the best possible degree the extent to which the shadow cast by the body becomes objectionable. In the letter case portion of the car, we must avoid any shadow on the letter cases or upon the apron in front of the cases, cast by the postal clerk working at these cases. Lighting units placed very far away from the face of the letter case causes the postal clerk to interpose his head and body between the light source and the letter case, which, naturally, results in objectionable shadows. It is therefore necessary to place the letter case units very close to the face of the cases.

The distance is really determined by the width of apron in front of the case. That determines where the clerk's head comes and, therefore, determines the point where the light should be placed. The distance is twenty inches from the base of the case with the present standard length of apron. With units placed down the center of the car and letter case units placed twenty inches in front of the letter cases, there will be no seriously objectionable shadows. This changes, as you realize, the practice of several roads. One railroad I happen to have in mind, places a line of fifty watt units about a foot off the center of the car, the idea being, evidently, that this will avoid shadows better than if they placed them on the center line. I find from practical experience in railroad service, as well as having tried some experiments, and from theory, that this does not work out satisfactorily; neither does the system of putting two lines of small sized units down the center of the car work out satisfactorily.

Turning to the question of light in the eye. We know, from our researches on this subject, that light emitted by a bare lamp, or even the diffused light about a reflector, with the reflector surrounding the lamp, has an effect in cutting down the efficiency with which the eye works. For instance, if I turn this desk light so that its rays fall directly in my eyes, the clearness with which I can see is materially decreased. Research made on this subject indicates that this is the case, even if I frost the lamp, or if I surround it with opal or prismatic glass or with any kind of diffisuing medium. It is, therefore, in so far as the postal clerk may look up and down the car in working, objectionable to have a light unit which emits a large amount of light towards the eye. We may say the clerk keeps his eyes down on the work and there is no importance in the fact that the light emits a large amount of light towards the eye, but this is a condition which only exists theoretically. In actual practice the mail clerk turns around to throw papers in the sacks behind him, or looks up and down the car to a greater or less degree, and the presence of a unit which emits a large amount of light above the angle of fifty degrees, or sixty degrees at the highest, is objectionable on that account.

In the matter of speculator reflection we are, throughout the illuminating engineering world, just beginning to realize the immense importance of obtaining a thoroughly diffused illumination. When we have a mirror before us we don't see the mirror, we see the object mirrored. The mirror itself is invisible. If there is a light shining directly in the mirror, and I hold the mirror here, I see the light in the mirror. Now let us suppose, instead of having a mirror before us we have an ordinary printed sheet with little mirror specks, little specks of silver we will say, scattered over the surface. We read the letters, but we are getting sent into the eye, along the line of vision, some very intense beams of light. The effect is such as to cut down the effectiveness with which the eye works, to increase fatigue and, if long continued, to produce permanent eye strain. Now a glazed paper acts like such a paper as I have described, with little specks of mirror scattered over it; even the most diffused paper that can be used is not entirely immune. I am not speaking of blotting paper because that couldn't be employed in practice, but take the very diffused surface of a newspaper, still, sometimes, there is a good deal of specular reflected light entering the eye. To avoid the evil which is incident to that, we should work with the greatest diffuseness of illumination possible. The greatest diffusion that is practicable would be obtained by an indirect lighting system; the next most satisfactory would be with a direct lighting system, with the light derived from reflectors whose interior surface is either depolished opal glass or of such character that the entire interior surface reflects the light rather than the view of the light source. The worst condition, for lack of diffuse illumination, is that given by a mirrored reflector, (and the enameled metal reflector, so well known in postal car service, is a close second.) It is then a very important requirement, if we are to avoid eye strain, to obtain diffuse illumination.

The fourth requirement is that of getting adequate intensity. In illuminating engineering practice, and theory, one of the most important reasons for considering the question of intensity arises from the fact that the required intensity varies according to the diffuseness of the illumination produced. If we have an illumination which lacks diffusion we require a consider-

ably higher intensity for adequate vision than we do with illumination which is very diffuse. Even, however, if we provide that greater intensity of illumination which may be required with a known diffuse system, we do not, except for momentary values, get equally good results. The reason we require more illumination is that the eye is working at the least efficient state and, therefore, will produce a greater amount of fatigue although momentarily we may obtain greater results.

The intensity of illumination in general practice varies between two and three and a half foot candles, different authorities estimating differently for close work. Recent researches, made with particular reference to the most correct light, indicate two and one-fourth foot candles as a minimum that is satisfactory for continued work and three and one-half as an ample value.

The meeting, then, of the first requirement of postal car lighting, that of producing a condition favorable to the maximum efficiency of the eye with minimum eye strain, will be accomplished if first we place our main light units in the center line of the car, thus avoiding shadows, and placing letter case units twenty inches from the letter case; if we choose a reflector which sends a minimum amount of light into the eyes; if we choose a unit which produces as diffuse reflection as possible; and finally if we provide enough units, or units of sufficient size, so that we have an intensity of at least two and one-fourth foot candles under all conditions of service, at all points where close work is to be done.

Turning then to the question of efficiency. The efficiency, of course, varies very considerably with the different types of reflector employed. The efficiency of generation, the efficiency of utilization, and eye efficiency are all of great importance. Efficiency of generation is not the purpose of this paper at all. That is the problem that the incandescent lamp manufacturer and the manufacturer of gas lighting appliances is primarily concerned with. We have, however, the other two efficiencies that the illuminating engineer is more particularly, and directly, concerned with; that of utilization, the efficiency with which your light energy generated is carried from one point to another, which means to the point where the light is to be used; and then, finally, this question we have already discussed very briefly, eye efficiency.

The efficiency with which light is to be translated to the point where it is to be used, that is, from seven or eight feet above the floor to the plane where it is going to be used, depends upon the particular translating device, in other words, the reflector employed. The most efficient type of reflector, considering only the delivery of maximum light energy at the point where it is desired to be used, is the mirrored reflector. In postal car service the mirrored reflector will deliver, on the plane where it is to be used, sixty-two per cent of the total light flux of the lamp. That is to say, for every hundred lumens generated by the bare lamp, the lamp without reflector, sixty-two of those lumens will later be delivered on the plane forty-six inches above the floor. That represents the highest efficiency that we know, today, how to produce.

Next in efficiency comes the prismatic clear reflector. The prismatic clear reflector delivers fifty-five per cent of the light, generated by the bare lamp, upon the plane of utilization.

With a heavy density opal reflector especially designed for this service, we can deliver fifty-two per cent on the plane of utilization. I will later show you that it does not follow that any heavy density opal reflector will deliver fifty-two per cent. Neither will the figure fifty-five per cent for prismatic reflectors apply to every prismatic reflector. A change of only three-fourths of an inch in the zone of position may cause the loss of as much as seventeen or eighteen per cent in the amount of light delivered; but I am giving you figures indicating the best that can be accomplished with the different media in the present state of the art, and indicating not only the best, but what is generally accomplished by the existing reflectors, and existing prismatic reflectors give fifty-five per cent, and the best heavy density opal reflectors will give fifty-two per cent.

I might interject, here, the comment that in speaking before you I am using the term opal reflectors to include all reflectors covered by the various trade names which have "milk-glass" and "white-glass" and terms of that sort. Some of those reflectors differ chemically from others; they all act physically exactly the same. The physical laws of the light action of those different reflectors are identical, and they differ, of course, only according to the density of the reflector; that is to say, the results will differ according to density in relation to the glazing of the reflector, and according to the whiteness of the particles; but the physical laws governing the operation of milk glass, white glass, opal glass, opaline glass are identical, and, therefore, for all practical purposes in illuminating engineering they can be classed together, however much they may differ in chemical characteristics, and however much they may differ in artistic appearance.

The aluminumized metal reflector will deliver forty-four per cent of the generated light flux on the plane of utilization. You see we are dropping along here very materially; sixty-two per cent mirrored reflection; fifty-five per cent prismatic; fifty-two per cent heavy density opal, and now forty-four per cent for the aluminumized metal reflector. The best medium density opal reflectors which are today developed for postal car lighting service will deliver forty-three per cent of the total generated flux. The poorest reflector of the medium density opal type with which I am familiar, that has been applied to car lighting, will deliver thirty-nine per cent of the total flux. The prismatic satin finished reflector delivers thirty-nine per cent; in other words, a satin finished reflector is equivalent to about the poorest medium density opal reflector.

The light density opal reflector delivers forty per cent, there being only one type that is particularly applied to car lighting at the present time.

The porcelain enameled reflector delivers forty per cent of the total generated light flux on the plane of utilization. You will recall that the alminumized metal reflector delivers forty-four per cent; in other words, four per cent more than the enameled metal reflector.

One type of heavy density opal reflector which has been considered for car lighting work delivers only thirty-nine per cent of the total light flux. I give this figure to call your attention to the fact that a reflector may vary from thirty-nine per cent to fifty-two per cent in effciency with a media essentially the same; in one case the reflector is designed for the service and in the other case it is not. It is a huge mistake to think that all the science of reflector design rests with the mirrored reflector or with the prismatic reflector. There is a large difference in the results that can be obtained with the opal reflector as well as with the other types.

One type of reflecting and diffusing unit, which has been referred to by the manufacturers as a semi-indirect lighting unit, and particularly considered for postal car lighting, delivers thirty-two per cent of the light flux of the bare lamp. That indicates about the lowest point of any truly indirect unit, thirty-two per cent; in other words, it indicates about the value that would

come from any opal or other diffusing unit.

The bare lamp without reflector gives twenty-eight per cent of the total flux of the lamp.

Indirect lighting will vary somewhat according to the condition of the headlining of the car and according to the particular type of reflectors used, but a fair general figure applying to the service would be twenty-five per cent. That represents the value obtained with what is ordinary called a white ceiling. With white ceilings and white headlinings the co-efficient of reflection will practically never exceed seventy per cent and frequently falls below sixty.

Those figures will give you a general idea of efficiency values which we are concerned with in postal car lighting. You see that they vary from sixty-two per cent, in one case, with a reflector, to twenty-eight per cent with a bare lamp; in other words, we more than double the illumination, very considerably more than double the illumination, by the employment of a reflector of the most efficient type, and even the least efficient type of reflector gives you about twenty-five per cent increase in illumination, in addition shielding the eyes from the light of the bare lamp.

The question would naturally interest as as to whether or not the efficiency of the installation would be effected by the separation of light units. Suppose in one case we employed units separated five feet and in another case ten feet, with larger sized units, would there be a material difference in the efficiency of the installation between these limits. I will say there will be no material difference. The difference would be that of about a per cent, in other words negligible; nor would there be any difference in efficiency due to the size of lamps. If we generate approximately two hundred lumens with the twenty-five watt lamp and employ twenty-six lamps, or if we generate four hundred lumens with the fifty watt lamp and employ thirteen lamps, we get practically identical illumination results. We also get very identical conditions in the matter of uniformity. Obviously there will be no difference between the thirty volt and sixty volt lamps. The efficiency is not affected by spacing, the size of the lamps or the voltage of the lamps.

It is interesting to note that the considerations already set before you in this meeting rather place a premium on the use of fifty watt rather than the small sized lamps. First of all, it has been shown that the requirements are for units to be placed in the center line of the car. If we put units in the center line of the car, with twenty-five watt or fifteen watt lamps, we are obliged to make very close spacing. We have the same wiring difficulty, only with a double number of outlets. We have a double number of fixtures, or pehaps if the fifteen watt units are used we have still a larger number. In other words, from a consideration of all points set forth, I believe there is a powerful incentive to the railway engineer to use fifty watt lamps entirely. Equally good results can be obtained with fifteen watt or with twenty-five watt lamps, as far as illumination goes, but I believe that the advantages of going to a fifty watt system will outweigh the advantages of carrying two stocks of lamps, in the case of those roads that now standardize on other sizes than fifty watt. I would commend to the attention of those employing other than fifty watt lamps the very serious consideration whether it will not be at once desirable to adopt the fifty watt unit in all new cars, because of the advantages incident to the smaller number of light units.

Turning to the question of minor requirements, we approach that very delicate subject of maintenance. I have very definitely expressed at the beginning of this paper my attitude on that subject. At the worst the maintenance cost in dollars and cents is a ridiculously small cost as measured against the importance of the work done on the system. That is not peculiarly true of postal car lighting, it is extremely true of industrial lighting. It is very true of office lighting. It is true of all lighting where work for utilitarian purposes is done with light. The maintenance cost is insignificant beside the cost of the labor and material involved in the work under the lighting system. That being the case, it seems almost self evident that any money spent in maintenance, which will produce a material improvement in the service, is money well spent. In this particular case of postal car lighting, the United States Railway Mail service may properly ask the railroads to look after a first class maintenance in order to make the conditions such as will give best results in the service in question. Of course, if a type of unit be used which gives a very diffused illumination and does not give much light in the eye, the service will not greatly suffer if the railway engineer gives a large factor of safety and counts on heavy depreciation before he looks after the maintenance of reflector equipment and the renewal of lamps. But the cost involved in so doing, the cost of additional fixtures, the cost, even small though it may be, of current involved, the cost features involved in giving that great factor of safety, are very large indeed compared with the costs involved in careful and adequate maintenance.

Though I have individually given expression to my viewpoint on that subject to a number of people before, I wish to take this occasion again to recommend, in the maintenance of car lighting units, the cleaning of reflectors separate from the car, and to recommend the proper equipment of those entrusted with the duty of cleaning the reflectors so that they can enter a car with a load of clean reflectors and leave the car with a load of dirty ones, cleaning the reflectors at a separate point, without interruption to the service.

Summing up the data, that we have already considered in the light of first cost, the first cost of the unit, is of course greatest with either a mirrored or prismatic type of reflector. Those two types of reflector represent greater cost in manufacture than any other type. A close second is the enameled metal reflector. The various opal reflectors, and the aluminumized metal reflector are by the intrinsic cheapness of manufacture of much lower cost. The breakage of course will be the least with the enameled metal or aluminumized metal reflector.

Summing up then the advantages of the different types we find that the mirrored reflector is the most efficient in delivering the light energy at the point where it is desired to use it, but the worst in point of giving diffused illumination, thus involving maximum eye strain. That one feature would probably discredit it for its general use in car lighting. The prismatic reflector is efficient for that service, but it is subject to breakage in handling and cleaning; it involves a greater difficulty in cleaning than some other types, and it is certainly no better, probably appreciably poorer, than some of the best types in point of giving a diffused illumination. The best of the opal reflectors show up very satisfactory for car lighting except in the matter of breakage and the matter of delivering a certain amount of light in the eyes. The aluminumized metal reflector would seem to be, of all types, considered decidedly the best, striking the best balance between conflicting requirements. It marks fourth in order of efficiency, appreciably above the opal reflector, and above the enameled metal reflector. It does not involve breakage. It gives

a very satisfactory type of illumination, and in short has only the one disadvantage of involving greater maintenance cost than such types as the enameled metal type.

It would appeal to me that the solution, for the immediate present, of postal car lighting lay in the proper placement of units as already suggested; in the employment for general service of aluminumized deep bowl metal reflectors; in the employment of enameled deep bowl metal reflectors only for that service where the dirt conditions are not normal but very excessive; and that it will be found of practical advantage to the railroad fraternity to employ the fifty watt lamp in this service even in cases where the lamp is not at present standard on the railway system. (Applause.)

Discussion.

Mr. Reed, Chairman of the Standard Car Committee of the Railway Mail Service, said that up to the present time every railroad system had built its cars according to its own ideas and the result is that we have a great variety of postal cars. The committee of which Mr. Reed is Chairman is appointed to draw up a standard specification both of construction, heating and lighting features, etc.

He stated that in postal service there is nothing that becomes of so much importance as good effective illumination. He said that operating reliability is the first essential. He said that effective illumination or ability to see to work is second. He said that in all probabilities the new specifications would require a dependability better than 99% based on the car movements, or more definitely, failures amounting to 2/3 of 1 % of the total car movements will undoubtedly be considered as maximum.

He said that the specifications would also cover the arrangement and the density of lights, the question of maintenance, in fact everything which would be important in maintaining efficient light in postal cars.

He said that in order to improve the day light illumination they were placing a sky light in the roof of the cars over the letter case end. They are also closing the deck sash permanently and removing the cinder screens which greatly increases the day light illumination of the deck sash.

Upon being asked what he considered would be the basis for determining whether or not a light failure occurred Mr. Reed stated that this would be made on the basis of a reasonable efficiency that permits of carrying on postal work.

Mr. Reed said that he considered that car lighting was of far greater importance than the average general manager is willing to admit. Mr. Reed was asked if this 2/3 of 1 % failure would apply to individual cars or on an average of all cars operated. He said that the average would be taken of cars operating over each of the railway mail divisions, for instance Pittsburgh and Chicago on the Pennsylvania, Chicago and Cincinnati on the Big Four, etc.

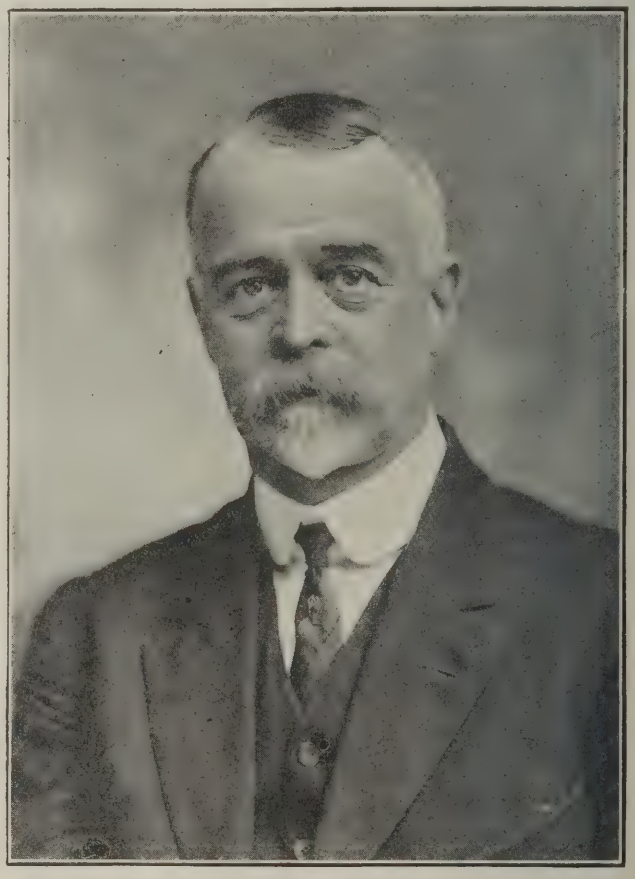
As to train lines Mr. Reed considered that they would make no specification, this wiring being done in accordance standard practice of the railway company. Upon being asked whether or not these specifications would be retroactive, Mr. Reed stated that it would be entirely a question of policy for Congress or the Postmaster General to decide.

Election of Officers of A. R. E. E.

The election of officers of the Association of the Railway Electrical Engineers was then taken up and the following officers were elected for the ensuing year. D. J. Cartwright, Electrical Engineer, Lehigh Valley, President; C. R. Gilman, Chief Electrician, Chicago, Milwaukee & St. Paul, First Vice-President; H. C. Meloy, Chief Electrician, Lake Shore & Michigan Southern, Second Vice-President; Joseph A. Andreucetti, General Foreman, Chicago & Northwestern, Secretary and Treasurer. The following Executive Committee was also elected: L. S. Billau, Assistant Electrical Engineer, Baltimore & Ohio; E. W. Jansen, Electrical Engineer, Illinois Central; F. E. Hutchison, Chief Electrician, Chicago, Rock Island & Pacific; C. J. Causland, Chief Electrician, Pennsylvania Railroad; Willard Doud, Shop Engineer, Illinois Central, and W. A. Del Mar, Electrical Engineer, New York Central & Hudson River. The next annual meeting will be held in Chicago and the semi-annual meeting in Atlantic City.

Mr. D. J. Cartwright

Mr. D. J. Cartwright, just elected President of the Association of the Railway Electrical Engineers, is a



D. J. Cartwright.

Bostonian but we can forgive him for that for he has been in the car lighting game since 1891. He installed a primary battery system of electric light on a railway coach on the B. & P. R. R. He took a special course of electrical engineering in the Mass., Inst., of Tech.

From 1887 to 1898 however, he was side tracked on general construction work and during the Spanish War he was employed in torpedo defense work in Boston and continued in that department until 1902 during which time he had charge of all electric construction and submarine work connected with Boston harbor and vicinity.

The next few years were devoted to the development of some of his own electrical inventions both here and abroad in connection with the operating of guns on board, ship, fuses for projectiles, internal combustion engines and carburetors.

From 1905 to 1907 he was elected in charge of car lighting for the N. Y. & N. H. H. Ry. 1908 to date he

has been with the L. V. R. R., and now has the title of electrical engineer.

Mr. Cartwright is a good live wire and a man that does things so we can be sure that the Association matters are going to be carried on actively with D. J. in the chair.

Godfrey H. Atkin.

Godfrey H. Atkin newly elected President of the Railway Electric Supply Manufacturers' Association is Manager of the Chicago Office of the Electric Storage Battery

Godfrey H. Atkin.

Company, Philadelphia, Manufacturers of the "Chloride Accumulator" and "Exide" batteries. Mr. Atkin has been connected with electrical business in the west since 1890 when he joined the Chicago office of the Thompson-Houston Electric Company, afterwards merged into the General Electric Company. He has been with the Electric Storage Battery Company since 1902. He was born in England and although christened by his parents Godfrey Harold he is generally known to his familiars and to his business associates as "Tommy" Atkin. He is also Vice Chairman of the Chicago Branch of the Electric Vehicle Association and a member of the following clubs:

Mid-day
South Shore Country
Chicago Athletic
Evanston Yacht
Chicago Yacht
Royal Canadian Yacht Club of Toronto, Can.

Mr. Atkin is devoted to Yachting and is the owner and skipper of the schooner "Nomad."

Election of Officers Ry. Elec. Supply Mfgrs.

The election of officers of the Railway Electrical Supply Manufacturers Association were as follow: G. H. Atkin, Chicago Manager of the Electric Storage Battery

Geare, Fisher, Hersch, Andy and Cole.

Co., President; C. W. Bender, Commercial Engineer, National Electric Lamp Association, Vice-President, East; Wm. F. Bauer, Chicago Manager, U. S. Light & Heating Co., Vice-President, West; Edward Wray, Editor, *Railway Electrical Engineer,* Treasurer. The new Executive Committee is as follows: R. M. Newbold, Adams & Westlake Co.; J. M. Lorenz, Central Electric Co.; Otis B. Duncan, J. Lang Electric Co.; W. E. Ballatine, Willard Storage Battery Co.; J. G. Van Winkle, Safety Car Heating & Lighting Co.; C. W.; Bender, National Electric Lamp Association; Geo. H. Porter, Manager Railway Sales, Western Electric Co.; B. L. Winchell, Jr., Chicago Manager, Kerite Insulated Wire & Cable Co.; L. J. Kennedy, Chicago Manager, Consolidated Railway Electric Lighting & Equipment Co.

SHOP SECTION

EDITED BY

GEO. W. CRAVENS

The Visit to Burnside Shops of Illinois Central R. R.

On Friday afternoon, October 25, a large party of the members of the Association of Railway Electrical Engineers visited the Burnside Shops of the Illinois Central Railroad to inspect the main features of the electrification, with special reference to the recent large extensions.

Originally these shops were operated by steam engines located at various places about the plant; then about 65 motors were installed to operate various groups and individual machines, these motors being for operation on a 250 volt direct current circuit and supplied from small generators in a centrally located engine room; and now about two hundred 440 volt alternating current, three phase motors have been installed to give electric drive for practically everything in the plant.

The party was in the care of Messrs. W. Doud, Shop Engineer, and E. W. Jansen, Elec. Eng. of the Road. The party first visited the car shops, passing through the paint shop and car repair shops. In one end of the repair shop is the car wheel shop in which the Westinghouse automatic controller for wheel lathes has been installed. This equipment attracted considerable attention, as did also the other induction motor starting and controlling devices.

The water cooling tower stands between the car

shops and the wood mill, and two 20 H.P. 440 volt, 3-phase induction motors drive the two large fans. These motors with their controlling apparatus stand in separate brick buildings at one end of the tower and are entirely independent.

The party then visited the wood mill and saw the remaining belt drives, these being kept as a measure of economy. The wood working machinery is driven by a steam engine in one corner of the old engine room, the shafting being driven one from the other by belts in the old manner.

The two new steam turbines are installed in an extension to the power plant, this being at one side of the wood mill. In here are the main switchboard, air compressors, pumps and the usual auxiliaries, the turbines being of the horizontal type and built by the Allis-Chalmers Company. They operate at a speed of 3800 R.P.M. and drive generators giving 900 amperes at 480 volts, 3-phase, 60 cycles, alternating. Le-Blanc jet condensers are used, being installed next to the turbines.

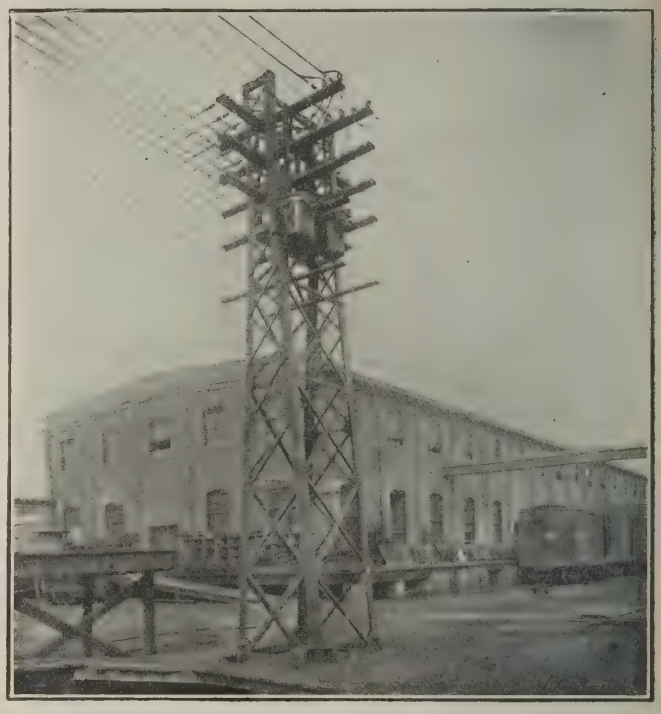
One of the exciters is driven by a steam turbine at 2400 R.P.M. (45 H.P., 120 lbs. steam) and is used for starting only. The other is driven by a 37½ H.P. motor at 850 R.P.M. and is used after the turbo-generator is running. Both of these machines set next to the turbines on the main floor. It was in this engine room that the first photograph of the party was taken. From here the party went through the wood mill and over to the boiler houses.

Just outside the main boiler house is the new concrete coal handling tower. In the lower room of this tower are all of the motor starters for the boiler

A Corner Tower of Transmission Line.

room, thus keeping them in one place and under the care of one responsible man. Installed beneath the floor, with openings in front of each ash pit, is a pneumatic ash remover. This operates on the vacuum principle, creating a powerful suction which carries off anything put into it. Mr. Doud dropped several bricks, entire and in pieces, into one of them and they were carried away as quickly and easily as the ashes. By improved methods the boiler capacity required has been reduced from 14 to 12 boilers for normal conditions, the balance now being available for extensions to plant and as spares. A 250 foot concrete stack, 9 feet inside diameter, has been built to replace the several smaller stacks originally used.

The Boiler and Tank Shop was next visited, where another photograph of the party was taken. In this shop there are twenty alternating current motors mounted on the walls, each taking the place of a direct current motor and driving a section of line shafting through a silent chain. One of the interesting features of this shop was a pneumatic riveter for the back plates of boilers, this being made to operate in a vertical position through raising the rear of the boiler up.



A Corner Tower with Transformers.

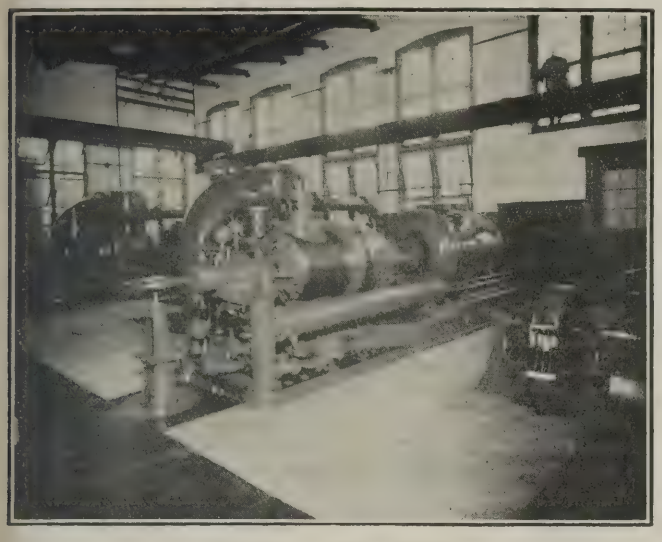
In the Blacksmith Shop there are motors for driving the line shafting, these replacing two steam engines which act as span wires, the same plan being followed in the car shop. From here the party went to the Locomotive, Machine and Erecting Shop.

In the Locomotive Shop the line shafting is also divided into sections with a motor for each section, with several of the larger machines equipped with individual motors. One of the most interesting of these is a large planer equipped with a reversing motor. The action is entirely automatic, being controlled by stops on the bed of the planer. A demonstration showed the action to be practically instantaneous regardless of the speed of travel or length of stroke.

Both direct and alternating current is used in these shops, but most of it is three phase, alternating at 60 cycles. The distribution line is carried on steel towers, 440 volts being used. Oil cooled transformers are mounted directly on the poles for stepping the current down to 110 and 220 volts for use in the buildings for lighting. The motors operate at 440 volts, in some cases being synchronous but mostly induction type. The distribution system attracted considerable attention, the very substantial towers being especially liked. In some cases as many as 13 wires and cables being on one tower, and at corners the towers

are strong enough to stand the unbalanced pull alone without guy wires.

The party enjoyed the trip very much and expressed their gratification to the gentlemen in charge



Interior of Power House.

very freely on the return trip. Such trips are fully worth while and should be a feature of the convention every year hereafter.

A. Wray Appointed Asst. Supt. Tel., Rock Island.

Mr. Archibald Wray, of Chicago, has just been appointed Assistant Superintendent of the Rock Island Lines, with headquarters in Chicago. Mr. Wray has had seventeen years experience in telephone and telegraph work with the American Telephone and Telegraph Company, the Telegraph Department of the C. B. & Q. Railway, and for the past four years has been employed by the Kellogg switchboard and Supply Company, of Chicago, as Railway Telephone Engineer.

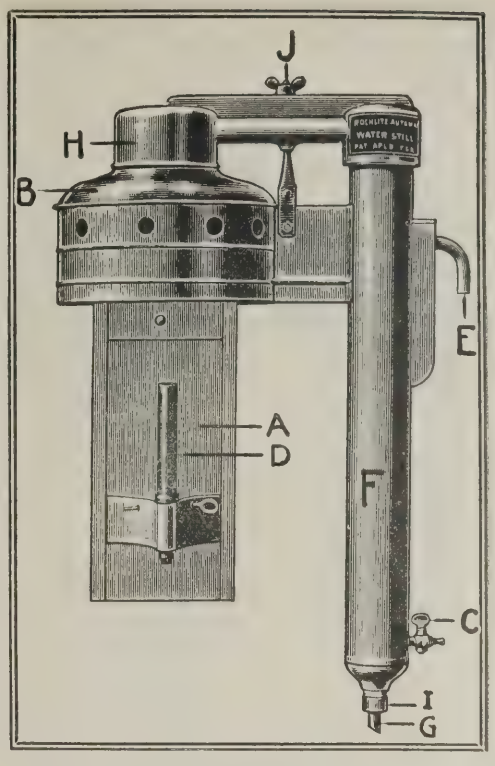
When in the employ of the C. B. & Q., which was one of the first railroads to adopt telephone train dispatching to any extent, Mr. Wray did much pioneer work in adapting the telephone to railway telegraph circuits.

In connection with Mr. G. A. Cummings, Mr. Wray developed the clock type selector, which was extensively applied to railroad service in the early days of the art. He has later been active in the development of other telegraph devices, such as the booster circuit, the telegraph typewriter, etc.

DISTILLED WATER FOR BATTERIES.

It is well known that distilled water should be used exclusively for flushing storage batteries as the impurities of the natural water are highly injurious to the battery plates. It is common practice however, in certain railroads to use condensation water from steam pipes, engines, etc., for this purpose. This too is extremely bad practice as the condensation water often contains oil boiler compounds and other impurities.

In an ordinary boiler the water is distilled at a much higher temperature than the normal boiling point of water so many of these impurities which are not volatile at 212 degrees are carried over with the steam. Realizing this situation the merits of the Rochlitz still are at once evident. This still delivers cold aerated and absolutely pure water direct from the apparatus. The water



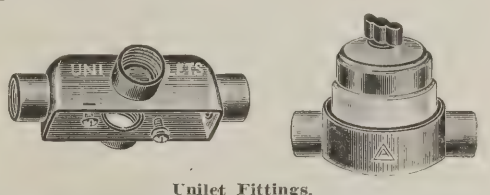
Rochlitz Still.

is absolutely pure because the temperature of the water is never carried above about 212 degrees and this is not sufficient to volatilize the impurities of the natural water.

This still is very economical both as to fuel and water; it is of good appearance and very substantial construction and is automatic in its operation. This still is handled by William M. Lalor, Manufacturing representatives, 500 Fisher Bldg.. Chicago, Ill.

"UNILET" FITTINGS

Railway engineers will be interested in the new line of "Unilet" fittings being placed on the market by the Appleton Electric Co. of Chicago.



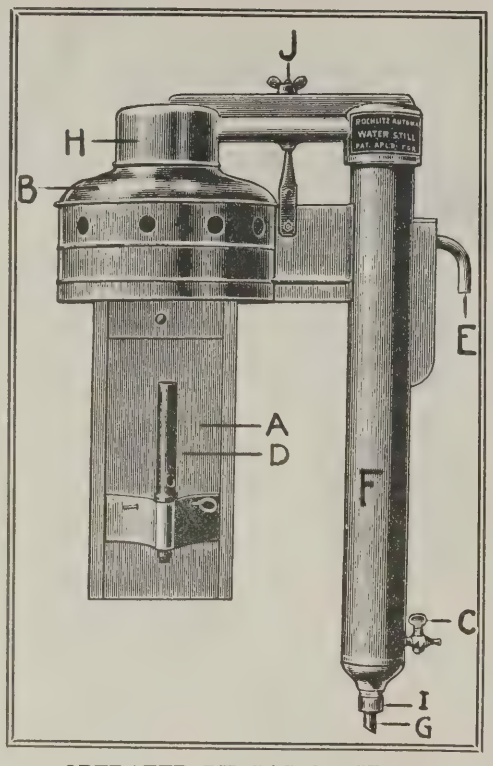
Unilet Fittings.

Being of steel, these fittings are therefore much stronger than any cast iron fittings now on the market, and at the same time affording much more room inside of the boxes to make and tape connections, etc. They have a very complete line of porcelain covers which fit snugly to the UNILETS, making an extremely neat job for conduit work.

UNILETS are furnished with a sherardized finish, which makes them practically rust proof and at the

Unilet Fittings.

same time leaving the threads in the nipples good and clean for screwing on the pipe. If so desired, they may be obtained with a coat of black japan enamel.



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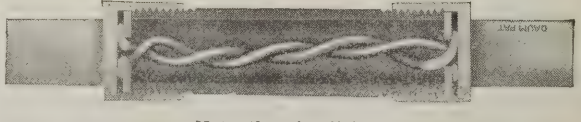

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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Four Ply vs. Five Ply Belt.

One of the big items in car lighting costs is that of belting, and the question of belt thickness is one which should receive the careful attention of the engineers in charge of this equipment. General practice seems to have standardized on the five-inch belt for American equipment although the majority of European axle lighting generators are driven by three and four inch belts. As to thickness of belt, however, certain roads in this country use a four-ply belt while others use five-ply. The question of relative belt strength is a comparatively insignificant one, as the belts are normally operated at a pull of about one-third to one-sixth of their breaking strength. The question of pliability, however, is a more important one, and one which materially affects the life of the belt in car lighting service where ten-inch, and in some cases eight-inch armature pulleys are used. When considered in this light the advantages of a more flexible four-ply belt becomes evident.

One large railroad of the middle west, about two years ago, changed from a five-ply standard rubber belt to a four-ply belt of the same make. The average belt life on that road for the past year has increased 25 per cent over what it was under the same operative conditions for the years previous.

This is a rather conclusive argument of the advantages of the four-ply over the five-ply belt for car lighting service.

Ball Bearings.

The fact that ball bearings are now being applied to railway car lighting generators with every type of axle lighting equipment is another testimonial of the energetic development and design of new equipment by the manufacturers, with a view of increasing the reliability, improving the service and reducing the cost of maintenance of the equipment.

The article on ball bearings published in this issue, which is the first of a series of educational articles written by each of the manufacturers of the various types of ball and roller bearings, gives much light on this subject which is such a new departure in car lighting lines.

Although ball bearings have been employed in car lighting service for but about a year, the modern bearing is by no means a new or untried device. In automobile service they have reached a high state of development both as to accuracy of manufacture and in the understanding of the proper maintenance by the users to give maximum life and greatest reliability.

As stated in this article, the car lighting problem is largely one of maintenance, and bearing maintenance is by no means a small item in the total maintenance cost. A large number of the total car lighting failures, moreover, may be traced directly to bearing troubles. These failures are usually of a very serious nature, resulting often times in dropping the revolving armature down on the generator pole pieces, where it grinds to pieces and often requires the entire replacement of the armature.

A bearing that will operate satisfactorily for 25,000 miles without any inspection whatever, and then only require the twist of a grease cup to inject a fresh quantity of lubricator, is without question a matter which commands the attention of every car lighting man. The interest on the comparatively high initial cost of this bearing when balanced against the saving in inspection, maintenance, repairs, and above all, the increased reliability of the service, fades into insignificance.

Ozone.

Medical authorities tell us that foul air in a railway car or any other enclosed apartment is not due to the presence of carbon dioxide, as has been generally supposed, so much as it is due to the presence of carbonaceous animal matter suspended in the air, high humidity, high temperature, and lack of air motion. Where humidity and temperature are maintained at normal value, and a reasonable amount of air motion is maintained, the effect of "stuffiness" may not be noticed even though the carbon dioxide content of the air become abnormally high. Probably one of the main influences in producing the effect of stuffiness is bad odors generally caused by the carbonaceous matter suspended in the air.

Ozone is merely oxygen in a peculiar state of activity which makes it a very rapid oxidizing agent. When generated in even comparatively small quantities, ozone will very soon oxidize this carbonaceous matter in the air, and by removing the cause of these bad odors, will clear up the atmosphere in the car and give the effect of freshness to the person breathing that air.

Ozone machines are now made in comparatively

small sizes which can be operated from the ordinary car lighting voltages of 30 to 60 volts, so that this offers another possibility to the ever zealous passenger department for improving the service of our best trains.

Association News

At the first meeting of the A. R. E. E. Executive Committee following Annual Convention, which was held Saturday, November 30th, it was decided to appoint committees as per the following schedule.

1. Committee on Standards.
2. Committe on Illumination.
3. Committee on Questions for Discussion and Investigation.
4. Committee on Electric Headlights.
5. Committee on Organization of Yard Forces.
6. Committee on Railway Power Plants.
7. Committee on Terminal Specifications for Handling Car Linghting Equipment.
8. Committee on Storage Batteries.
9. Committee on Headend Equipment.
10. Committee on Outside Construction and Yard Lighting.
11. Committee on Data and Information, and the Question Box.
12. Committee on Specifications.
13. Committee on Dynamo Suspensions.
14. Committee on Installation of Wiring in Railway Buildings.
15. Committee on Shop Practice.
16. Committee on Standard Reports for Operating Car Lighting Equipment.
17. Committee on Methods of Charging Storage Batteries.
18. Auditing Committee.

It will be noticed that there are a number of new committees appointed for next year's work which will without doubt still further increase the scope and effectiveness of the work of this Association. It is the plan for the Committee on Data and Information to open a question box in the columns of the RAILWAY ELECTRICAL ENGINEER in which questions will both be asked and answered.

The personel of the various committees has been appointed, but as we go to press, and the acceptances of these appointments have not yet been received, so they cannot be published until our January issue.

New Santa Fe Cars

The chair car shown herewith is typical of the design of sixty cars which have recently been built for the Atchison, Topeka & Santa Fe Ry. The complete order consisted of chair cars, smokers, and combination cars, the last of which are just being received. The cars are of steel underframe construction and the interior is decorted with a light mahogany finish. A feature of particular interest in connection with these cars is the electric lighting fixture, and particularly the reflector employed. This reflector is, we believe, the first opal reflector which has been especially and exclusively designed for car lighting service.

Fig. 1. New White Iris Car Lighting Reflector.

The reflector is made of a comparatively new type of opal glass, known under the trade name of White Iris. In optical characteristics, this glass is classed as a heavy density opal. The reflectors are equally notable for their remarkably high illuminating efficiency and for their unusually attractive appearance.

When cold, the reflector has a strikingly beautiful surface, having a mother-of-pearl appearance, with rich iridescent colors. When lighted, the mother-of-pearl appearance changes under the influence of the transmitted light to a rich light brown color, which harmonizes especially well with the light mahogany woodwork of the car. The outside surface of the reflector is relieved from too great plainness by raised ribs. The accompanying illustration gives an excellent idea of the shape and general character of the reflector, but gives very little idea of the remarkable color eeffcts of the reflector, whether lighted or cold. The smooth surface of the reflector makes cleaning especially easy, the ribs not adding in any appreciable degree to the difficulty of cleaning.

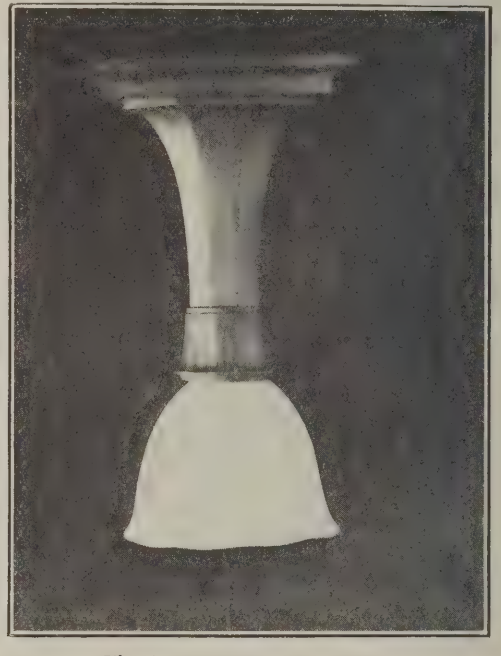


Fig. 2. Reflector with Fixture.

The general effect of the lighted car is very pleasing. The reflector comes well down over the 50 watt clear

bulb lamp, so that it is impossible to see any portion of the lamp filament in any normal position of the eye. The reflector transmits comparatively little light through its sides, so that all effects of glare or ocular discomfort are notably absent.

The results of illumination tests, made on this car with a Sharpe-Millar illuminometer, are given in the following diagrams and tables. Even a cursory inspection of the test data at once draws attention to the efficiency, which is remarkably high for an opal reflector installation. It will be noted that an average illumination of over three foot candles is supplied to the passengers in the aisle seats while over two foot candles intensity is provided at the window seats.

Fig. 3. Interior of Car Under Partially Daylight Conditions.

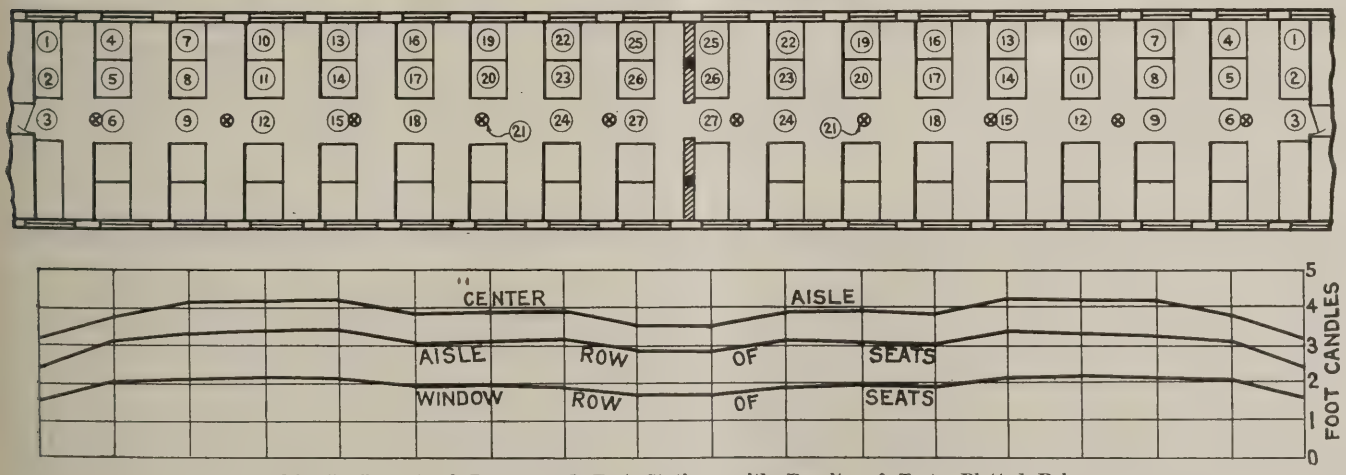


Fig. 5. Layout of Lamps and Test Stations with Results of Tests Plotted Below.

RESULTS OF TEST.

Station Number	Ft. Candles Illumination.	Station Number	Ft. Candles Illumination.	Station Number	Ft. Candles Illumination.	Station Number	Ft. Candles Illumination.
1	1.60	8	3.24	15	4.26	22	1.92
2	2.39	9	4.12	16	1.98	23	3.15
3	3.14	10	2.15	17	3.04	24	3.89
4	2.02	11	3.26	18	3.97	25	1.73
5	3.11	12	4.14	19	1.99	26	2.85
6	3.80	13	2.14	20	3.05	27	3.52
7	2.04	14	3.39	21	3.93		

Readings taken 33 inches above the floor.

The complete fixture equipment was supplied by the Safety Car Heating and Lighting Company, the White

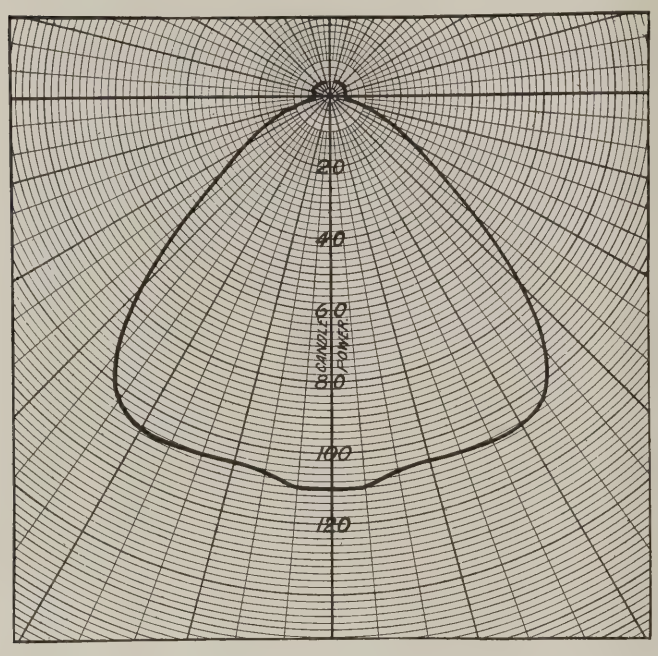


Fig. 4. Photometric Curve of Reflector.

Iris reflectors having been especially designed and manufactured by the Holophane Works of General Electric Company for this particular equipment.

A NEW SYSTEM FOR THE ELECTRIC LIGHTING OF TRAINS.*

BY P. AMSLER.

Where an overhead voltage of 600 volts is used, the usual plan for car lighting has been to put five lamps in series on the full applied voltage. An incidental disadvantage of this plan lies in the fact that a breakage of one lamp extinguishes the whole five. Lately the overhead voltage has been raised in several cases, and the direct-series method has become impossible. The main obection, of course, lies in the fact that too many lamps require to be joined in series, or, alternatively, the voltage of the lamps must be high; in either case the objections are evident. Voltages up to 1,200 can be dealt with to some extent by a machine with two commutators. This implies a three-wire system with a voltage of 600 between the middle and each of the outer conductors; the usual series-method could, therefore, be applied in this case. But, even so, there remains the danger of a defect in one of the armature windings which might have the disastrous effect of throwing the whole of the 1,200 volts on one set of lamps.

The author has elaborated a method which is worked by Brown, Boveri & Co. This plan has none of the disadvantages above-mentioned, and allows the use of low voltages on the lamps, independently of the high overhead voltage. The lighting unit consists of two machines. One of these is a motor, which takes the whole applied voltage, and has two commutators and two armatures, which are joined in series; the other is a generator, which can be wound so as to generate any required voltage, say between 30 and 50, and thus allow the use of metal filaments, all connected in parallel. At voltages of this order, metal filaments have been found to be sufficiently strong to withstand the vibration of railway traffic, and lately metal filaments, taking 100 volts, have been used with success; moreover, they are, of course more economical and less sensitive to slight variations of pressure. The lighting unit must have a nearly constant speed, which requires a shunt-wound motor. Machines of small outputs, say, for 1-6 kw., if run on 1,200 volts, cannot be shunt wound, because this would mean too thin a gauge of wire. This can be overcome by making the magnet windings a shunt to the terminals of the generator, and, seeing that motor and generator are rigidly connected together; the requisite characteristics of a shunt-wound motor can be obtained in this way. A number of machines have been constructed on this system, the motors having a capacity of about 2 horsepower at 2,000 revolutions per minute. The connections are shown in the adjoining figure. Besides the above-mentioned exciter winding, the magnets have a small series winding, which starts the motor; otherwise the generator being at rest, there would be no voltage at the terminals of the shunt winding. In order that this series winding should have no effect on the speed of the motor, there is a compensating winding in the opposite direction, which carries the main current of the generator. Both currents, therefore, are nearly proportional to the load on the generator, and tend to neutralize one another as soon as the machine starts, the result being that the motor has a genuine shunt characteristic. The series windings on the motor are on the earthed side, so that only the armature windings are really exposed to the high pressure, and even in case of short-circuits the high pressure cannot reach the lamps. All windings consist of proportionately thick wire, and are of sufficient mechanical strength to resist vibrations and shock.

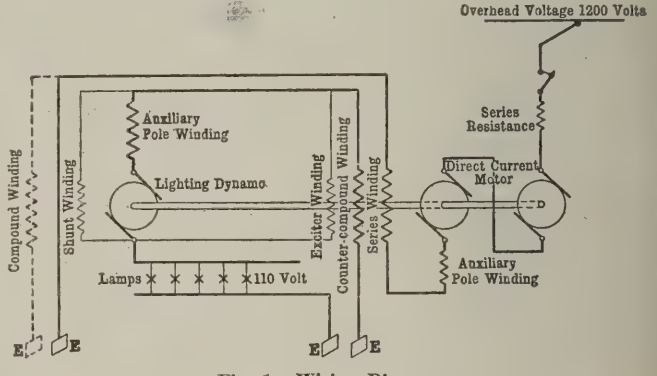


Fig. 1. Wiring Diagram.

Under test excellent results were given. In consequence of the sluggishness of the generator field, which reacts by producing a corresponding sluggishness of the shunt winding of the motor, it was found that within 1½ seconds of the start the speed of the motor had risen to 2,600 revolutions per minute; but at the end of two seconds it had fallen to the normal speed of 2,000 revolutions per minute. A short-lived variation of speed is probably quite reasonable, if it is only of momentary duration; there is, however, the possibility that the generator may not excite at the start, which would mean the entire destruction of the whole set. Fig. 1, however, shows an improvement which is introduced to meet this case, and also does away with the slight initial excess of speed, noted above. This improvement is shown in dotted lines, and consists in taking the main current of the motor on the earthed side through a field winding on the generator, thus tending to build up the generator

*Translated from Elektrotechnische Zeitschrift.

field at once. This provides an absolutely certain start, and the normal speed is reached in one second along a steady curve. A resistance of 27 ohms is permanently joined in series with the motor, and this means a steady loss of about 4 per cent. This allows the motor to be directly switched on to 1,200 volts without anything in the way of a graded starting resistance, which has to be mechanically or automatically operated. The maximum starting current is about 10 amperes, which is nearly five times the normal current. This starting process can be repeated several times in a minute without any heating of the motor or sparking at the commutator, even at the instant of switching on. In practical operation the removal and replacement of the collector on the overhead wire would be without any prejudicial effect on the lighting group; when the collector is replaced on the overhead conductor the lamps would light up, just as if they had been switched on in the usual way.

The apparatus is intended to be mounted beneath the floor of the car, and is protected by a sort of sheet-iron cover. In a test on a certain set it was found that the voltage on the lamps remained absolutely constant between no load and twice the normal full load, the voltage applied to the motor being, of course, constant throughout. No kind of automatic regulator is required. Any variation in the primary voltage—*i. e.*, in the overhead pressure—would reflect itself in the pressure on the lamps, and these variations produce quite permissibly small fluctuations in the light. But if the pressure on the lamps is required to be kept absolutely constant, irrespective of the pressure on the overhead wire, this can easily be arranged by a small automatic regulator in the exciter circuit of the generator.

On this system there has further been constructed a series of lighting groups, suitable for an overhead pressure of from 1,500 to 1,750 volts. The commutation with fixed brushes has been found to be absolutely sparkless, even up to loads exceeding the normal by 200 per cent., the normal load on the secondary side being 1-6 kw. The results of this work show that lighting sets can be constructed on this principle with outputs of 1-6 kw. for pressures up to 1,750 volts, and for 3 kw. up to 2,400 volts, and for larger outputs up to about 3,000 volts. The basis of these figures is found in the assumption that the armature is wound with wire of 0.5 mm. diameter, and that the mean difference of voltage between successive commutator segments is 35, which allows of a perfectly sparkless commutation. All other windings consist of thicker wire, which is very essential for steady work. Of special interest is the behavior of the lighting group if in normal working the overhead pressure fails—*e. g.*, owing to a fall of the collector bow. Since the collector also supplies current to the motors driving the train, there is a closed circuit through the motor of the lighting set and the main motor and rails. Thus there seems to be the risk of a short-circuit that might be dangerous. This, however, is not the case, as the following considerations show: As soon as the motor of the lighting set is disconnected from the overhead pressure, the counter E.M.F. of the armature generates a short-circuit current and the machine runs as a generator. This current causes a weakening of the field in the main winding of the motor, and neutralizes the field due to the compound winding of the generator. The generator, therefore, loses its voltage, which causes the exciting field in the motor to disappear and chokes out the short-circuiting current.

Ozone Generating System on the Central London Railways

During the eleven years which have elapsed since its opening, the Central London Railway has been ventilated on the exhaust system, the method consisting in closing all the doors underground for a certain period after the running of the last train, and drawing air right through the tube from one end to the other by means of a 200 h. p. exhaust fan fixed at Shepherd's Bush. This thorough cleaning out every night was supplemented by a continuous running exhaust fan at the British Museum Station, and the natural ventilating action of the running trains.

In view, however, of the increasing traffic, and particularly in anticipation of the very considerable augmentation which will follow upon the opening of the extensions to Liverpool Street and Ealing respectively, the progressive Chairman and Directors of the railway decided to install a more positive system of ventilation. With that enterprise and foresight which is always associated with the Central London Railway, the management decided to adopt an elaborate equipment to provide a continual influx during the whole of the day of a large quantity of fresh air treated with ozone to purify and improve its quality. This new installation, designed and constructed by Messrs. Ozonair, Ltd., in conjunction with Mr. E. P. Grove, Chief Engineer of the Central London Railway, has just been completed.

The Central London Railway runs from Wood Lane on the west side of London to the Bank of England in the centre of the City, a distance of nearly seven miles, and comprises two separate tunnels, having an aggregate length of about 13 miles. With the exception of a very short length between the first two stations—Wood Lane and Shepherd's Bush—the railway is entirely underground. The "up" and "down" lines are in practically separate tunnels, each 11 feet 8 inches in diameter, pierced in the London clay and formed of segments of cast-iron bolted together.

These tunnels are inter-connected at several points by "crossovers," that is, places where the trains can pass over from one tunnel into the other, when required. While this is very convenient from a traffic point of view, it unfortunately greatly increased the difficulties of the problem of ventilation. The tunnels follow the line of the Uxbridge Road, Bayswater Road, Oxford Street, Holborn and Cheapside, and are at a depth below the street surface varying from 60 to 100 feet, with thirteen underground stations.

Extensions at the City and to Liverpool Street Station, the terminus of the Great Eastern Railway, and at the other end, to Ealing Station on the Great Western Railway, are now in progress, and these will result in a considerable increase in the traffic, which already amounts to some 40,000,000 passengers per annum. The trains consist of from three to seven cars, one or two of which are provided with electric motors which receive continuous current from a third rail. The current

is supplied to the rails from four sub-stations, at the Notting Hill Gate, Marble Arch, Bond Street and Post Office Stations, which receive alternating current at a high pressure from the power-house at Shepherd's Bush. This power-house contains generating engines with a total capacity of over 11,000 horse-power.

At times of heavy traffic there are some 25 or more trains in the tunnels at the same time, each of which carries 330 passengers, more or less. Assuming that the trains are on an average three-quarters full, it will be seen that there are every day over 6,000 people in the trains, or including those on the platforms and lifts there may be as many as 10,000 in the tube continuously for two or three hours, and four of five thousand all day, so that the necessity for thorough ventilation is obvious.

Before entering into specific details as to the special installation for the ventilation of the railway on the Ozonair system, it would be well to consider the special properties and features of ozone when applied for ventilation purposes.

So long ago as 1785 Van Marum observed that oxygen gas through which an electric spark had been passed possessed a peculiar smell, and at once tarnished a bright surface of mercury.

For many years much doubt existed respecting the exact chemical nature of this oxidising principle, for the simple reason that it was found impossible to obtain ozone except in small quantities, and that an exact investigation of its composition was rendered still more difficult by its extremely energetic properties. Researches, however, conducted with the greatest care, have shown that ozone is nothing more than concentrated oxygen.

Ozone is present in minute quantities in the atmosphere. Its principal sources are probably the electric discharges during thunder storms, the silent discharge from thunder clouds, the evaporation of water (and especially of saline water, as in sea foam), and the action of some vegetable products on the air. Ozone is also

Fig. 2. View of One of the Fresh Air Intakes Above Ground.

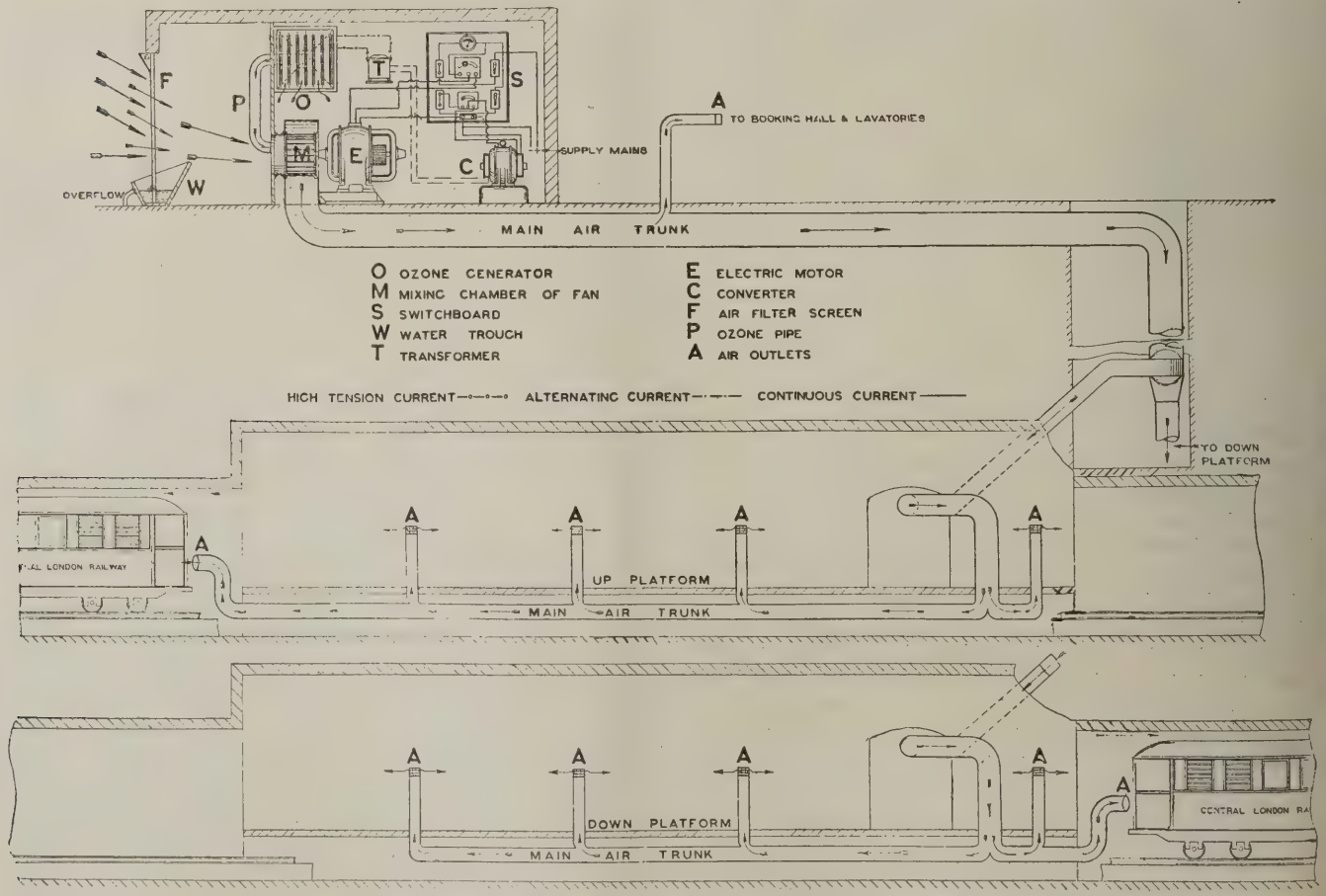


Fig. 1. Air Ducts and Detail of Ozone Generator and Ventilating System.

formed by the action of sunlight in the clouds. Ozone present in the atmosphere plays an important part in keeping the air pure and fresh, and destroying the deleterious organic matter constantly passing into the atmosphere from decomposing flesh, animal exhalations, etc.

Fig. 3. Stairway with Ventilating Duct Just Over Head.

According to that well known scientist—Douglas Galton—"The permanent absence of ozone from the air can be regarded as a proof that the air is contaminated."

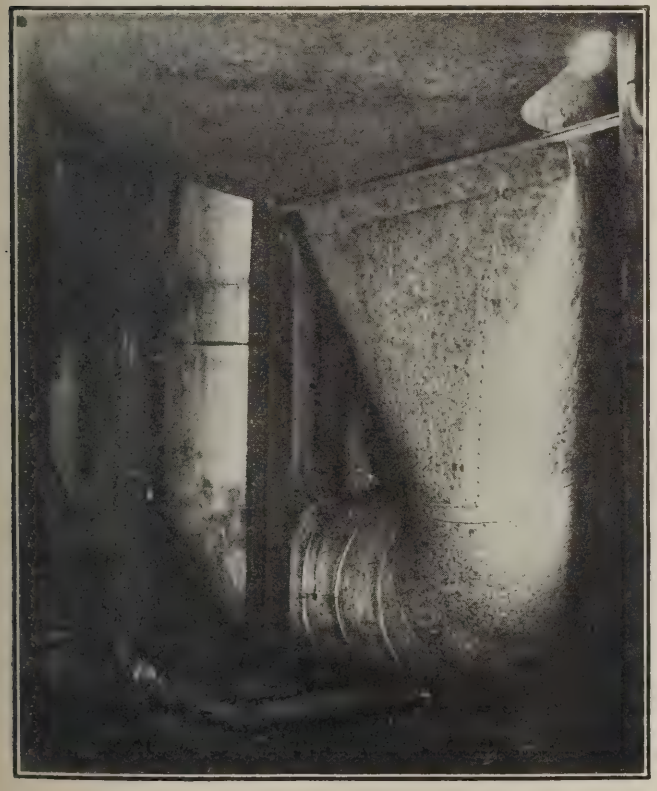


Fig. 4. One of the Many Problems in Duct Design.

Ozone, as already stated, unlike oxygen, is possessed of a very powerful and penetrating odour, and very silght traces of this gas can be readily detected by the sense of smell. It has the power of oxidising or destroying any offensive matter that the air may contain; indeed, it is the most powerful oxidising agent known, which is due to the fact that it readily parts with the third atom of oxygen contained in the molecule. The conversion of oxygen into ozone is expressed chemically by the equation $O^2+O=O^3$, and it is this third atom which splits off so easily and enters into the combination with other bodies that is the basis of its value for the purification of the atmosphere, etc.; in fact, it is the most powerful sterilising agent known.

THE VENTILATING SYSTEM.

The system consists briefly in drawing the air supply from as clean and pure a source as possible, and removing the smuts and other solid floating matter by means of special filtering screens. During this operation practically the whole of the sulphurous acid and other deleterious gases, met with in all large cities, are absorbed.

The cleaned air is then passed into a mixing chamber, where it is purified and partially sterilised by means of ozone. It is also enriched by the addition of a minute quantity of pure ozone, which gives it that beautifully refreshing character which the air at the seaside and on mountain tops is known to possess. From the chamber it is distributed by means of ducts, to the various parts of the building, or railway station, etc., as the case may be.

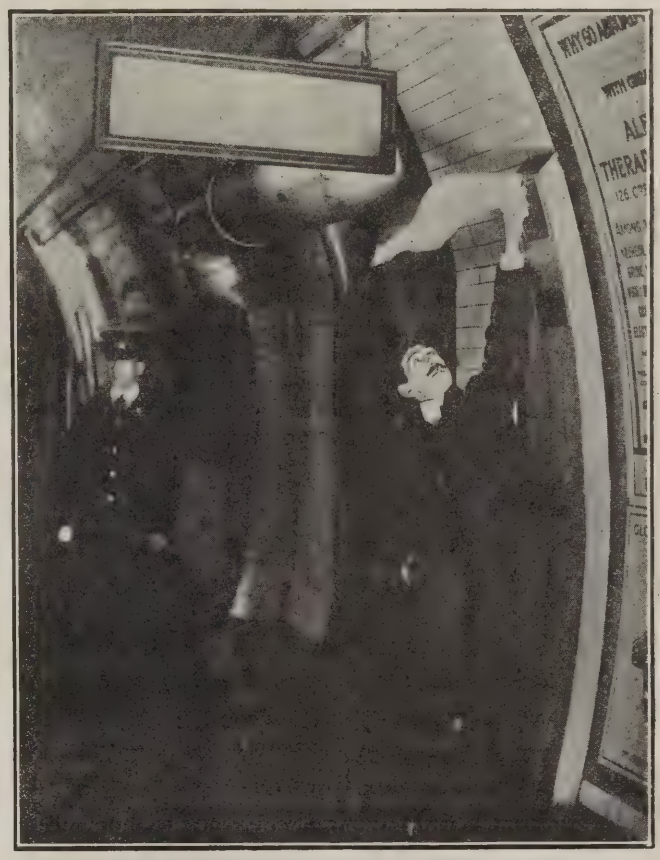


Fig. 5. Ozonated Air Delivered to the Platform.

The explanatory diagram, on the opposite page, illustrates graphically the general arrangement of one of these plants, and shows how the air is purified and ozonised and introduced into the tunnels. The actual generating plant is shown in the small room on the upper left hand side of the diagram. Commencing on the extreme left is the filter screen F. which cleans and washes the incoming air from all dirt and smuts, and at the same time absorbs all the deleterious gases, such as ammonia and sulphurous acid, which are always present in the

atmosphere of large cities. The air is drawn through the filter screen F by aid of a fan M which is driven by a powerful electric moter E. This screen is kept moistened by means of a continual flow of water from a series of jets at its upper edge. The used water is caught in the water-trough W.

The Ozone Generator.

is shown at O. The pattern supplied to the Central London Railway consists of a series of 10 generating units, each comprising a thin mica plate with a sheet of metallic gauze on either side, the set of 10 plates being spaced and mounted on insulating supports. The gauze sheets are connected across the secondary of a small transformer delivering alternating current at a pressurc of five thousand volts, and an innumerable number of minute discharges occur all over the opposing surfaces of the plates. In view of the very large volume of air dealt with in the Central London Railway plants, a comparatively strong mixture is produced in the ozone generator O, and this is conveyed by the ozone pipe P to the mixing chamber of the main ventilating fan M, where it is mixed with the main current of air, and thence blown down the main air trunk to the various distributing sheet metal ducts or conduits, as is illustrated diagrammatically in the figure; and is eventually delivered to those places where it is required. These air outlets are marked A on the diagram. Most of the Central London Railway equipments each pass normally some 360,000 cubic feet of air per hour, and the generator provides an amount of ozone sufficient to preserve the proper proportion. The proportion of ozone and the volume of air supplied can be regulated from the switchboards controlling each equipment.

The main ventilating fans are of the "Sirocco' pattern and are driven in most cases by 7½ h. p. motors. The ozone generator is supplied with current at 5,000 volts from a transformer T fed at 380 volts A. C. from a small 550 volt rotary converter C.

Pure Air.

The question of the purity of the air we breathe must always be one of the most engaging and serious problems. Whether the place be the home, the office, the workshop, the railway carriage, the place of amusement or even the street, the condition of the atmosphere is equally important. It can scarcely be too emphatically asserted that more than half the ills that people suffer from are due to slow poisoning produced by the foul air of the rooms of which we live and breathe. It is a popular belief that the contamination of the air of a place in which a number of persons are congregated, is due to an abnormal amount of carbonic acid gas. This is supposed to cause the stuffiness, smell and disagreeable taste usually perceived. Such, however, is far from the case. Carbonic acid gas is a tasteless and perfectly inodorous gas. It is also practically harmless except in concentration at least ten times as great as is ever met with in the worst cases of bad atmospheres. The fact is, that we are constantly throwing off from the skin and lungs the waste products of the body. These minute particles on coming into contact with the air immediately putrify. This added to supersaturation, due to the moisture contained in the exhaled breath, is the main cause of fœted atmospheres

Another factor, although perhaps not so important as the foregoing, is the absence of motion in the air. Unless the air is moving, the layer next to the skin becomes overheated and supersaturated with moisture, thus causing great discomfort. For this reason the refreshing breeze is welcomed in hot weather. A lady uses her fan in a close room for the same purpose.

Light: Its Use and Misuse

A Primer on "Illumination" Prepared by the Illuminating Engineering Society.

CONTINUED FROM LAST MONTH

PRECAUTIONS TO BE TAKEN IN PLACING AND SHADING LIGHTS.

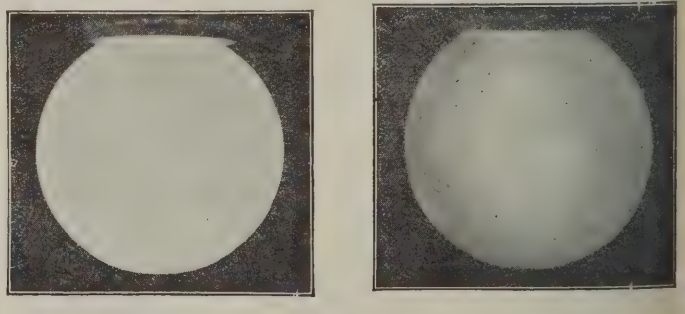
Diffusing and Shading by Globes and Reflectors.

In any artificial lighting the lamps should be so well shaded that the eye does not see them directly nor brilliant reflections from them. You can accomplish this end by putting the light in diffusing globes of, for instance, ground glass or white or opal glass or other translucent material. To secure the best diffusion, the globes should be dense enough not to reveal the form of the actual light source within, but to give the effect of the light pouring forth from the globe as a whole. (See Fig. 10.)

Another way of accomplishing the same result is to put a shade around the lamp, which screens it and reflects downward much of the light which would otherwise idly fall on the walls or ceiling. (See Fig. 11.) Such shades may be of mirrors or polished metal or white or opal glass, of ground or prismatic glass,—all of which, in a measure, work alike. Glass shades are generally preferable to metal ones, for a little light penetrates them sidewise,—just enough to keep the upper part of the room from being too dark.

Indirect Lighting.

Another scheme successfully used to shield the light is to turn the light from the lamp upward on to the ceiling by means of an opaque reflector underneath. The reflector conceals the lamp, and the brightly illuminated ceiling by which the light is diffused serves as the actual source of the illumination. (See Fig. 12.) This plan should be used only on white or very light ceilings and is subject to a heavier loss for securing diffusion than some other methods, but often this loss is reimbursed by the thoroughness with which the ceiling diffuses the rays that fall upon it.



Opal Glass Globe. Ground Glass Globe.

Fig. 10. Within each globe in a lamp of the same candle power. Note the superior d.ffusion of the light by the opal globe.

DON'T USE LOCAL LIGHTING BY ITSELF.

General Illumination Usually Best.

In ordinary cases general illumination is the best way of lighting an interior unless some of the work in hand, as sewing dark goods or reading very fine print, de-

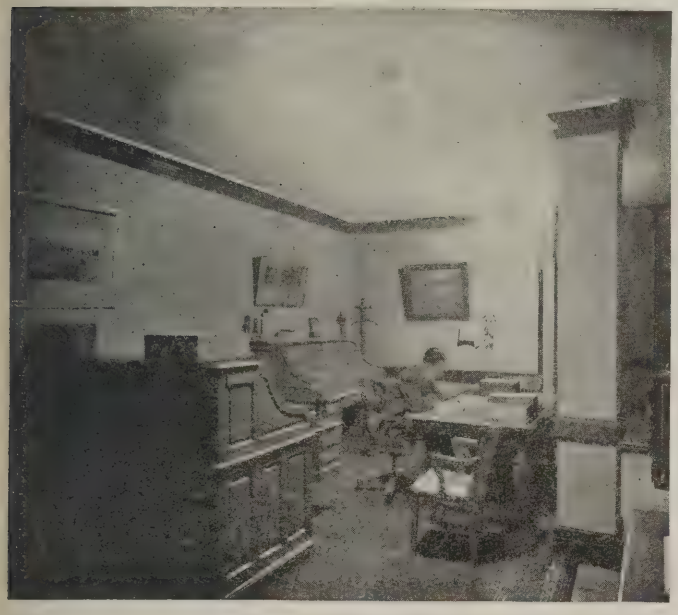


Fig. 11. General illumination by direct lighting, lamps concealed in diffusing glass reflectors.

mands an exceptionally strong lighting in some parts of the room. In this case local lights may be added, but they ought not to be used without pretty strong general illumination. The commonest sort of localized lighting is that furnished by a table lamp. Such a lamp should always be shaded to keep the direct light out of the eyes,—best by a translucent shade which will add something to the general illumination.

In any one of these plans for general illumination, lights should be so placed as to give at least fairly uniform lighting everywhere in a room, otherwise there may be strong and jarring contrasts of light and darkness.

In using shades open at the bottom, such as are very common, their shape and character can be so chosen as to distribute the light precisely as desired; this result can in less degree be accomplished by using enclosed globes or by indirect lighting.

Any of the schemes here sketched can be made to give good results. The choice between them turns upon just what task is required of the light and what its surroundings are to be. Ordinarily, lighting from shades open at the bottom gives a stronger light than other methods, but you must carefully avoid glare in these cases. Lighting by wholly indirect means, in which all the rays are diffused from the ceiling, demands lamps of extra power for the same illumination, but requires little care to avoid glare. Rooms lighted from diffusing globes take an intermediate position with respect to freedom from glare.

Misplaced Brackets.

For a lamp to do its best work, it should not be too near a wall, especially if this wall is dark. Hence only very small rooms can be well lighted by the usual side brackets, say 4 to 6 ft. high. In a large room the eye cannot avoid glare from such brackets unless their lamps are so heavily shaded as to dim the room. In large rooms where brackets can be placed high enough to be out of the general view, they may be used to advantage; and they are often convenient for occasional use, as in bedrooms, when the room is also lighted by other means.

ECONOMY AND EFFICIENCY.

Don't Waste Light by Using the Wrong Reflectors.

By using reflectors you can put the light from a lamp where it will do the most good, much as an automobile headlight sends the light along the road just where it is wanted. In fig. 3 there is a lamp without any shade or reflector and you will see that the light goes in all directions, only a small part of it falling on the level of the table where it is needed. The rest hits the walls and is reflected about the room losing intensity at each reflection. Obviously an unshaded lamp does not throw the light where it is wanted. To ensure the light falling upon the table you must use a reflector that will bring it there.

Of such reflectors there are three general types, either of glass or of metal, which we may call concentrating, semi-concentrating, and distributing. (See fig. 13, (a), (b) and (c). The first acts almost like an automobile headlight, throwing its light downward into a comparatively small area. The second kind spreads out the light over a much wider area, of diameter perhaps as great as the height of the lamp above the table, while the third is planned to light a comparatively big area not very intensely at any one spot.

No reflector ever increases the total light that streams out of a lamp; it only puts the light where it is needed instead of letting it go unguided.

DON'T USE SHALLOW REFLECTORS.

All reflectors should come far enough down over their lamps to prevent you from seeing the bright sources of light themselves without actually looking upward.

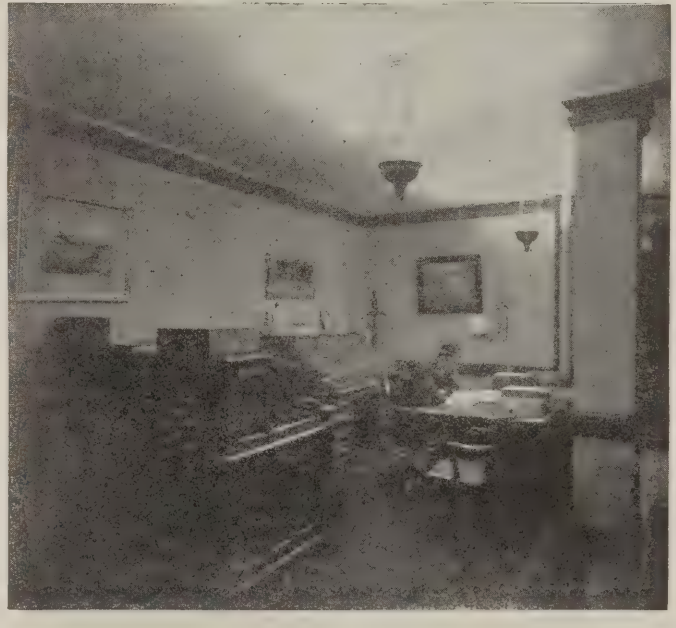


Fig. 12. General illumination by indirect lighting; lamps are concealed in opaque reflectors and the light is diffused from the ceiling.

Height of Lamps.

With proper reflectors, their height above the table, counter, or bench ordinarily makes little difference since it is the purpose of the reflectors to send the light where it will do the most good.

Effect of Dark Walls and Colored Globes.

Because dark walls absorb light strongly instead of reflecting it they demand much stronger lamps for sufficient illumination than do light walls. (See fig. 18.) A very dark wall-paper, or a dark wood finish may require three or four times as much light as a really light finish. Dark reds, greens, and browns reflect only 10 to 15 per cent. of the light which falls on them. White, cream color, and light yellowish tints may reflect over one-half the light.

Likewise, deeply tinted globes and shades absorb much light,—a fact which must be borne in mind in considering economy.

DON'T LET LAMPS AND GLOBES GET DIRTY.

Dirt on lamp chimneys, electric bulbs, globes, or reflectors absorbs and wastes much light. The country

(a) Concentrating Reflectors; lights a small area brilliantly.

(b) Semi-concentrating reflector; lights a larger area less brilliantly.

(c) Distributing reflector; lights a wide area moderately.

Fig. 13. Reflectors put the light where you want it; (a) (b) and (c) have lamps of the same candle power. (These pictures are intended only to show in a general way the effect of different types of reflectors.)

over, it is safe to say that millions of dollars are wasted every year by letting lamps become foul and dust laden. Nor is there any economy in using electric bulbs until they blacken. It pays to renew promptly blackened bulbs and defective gas mantles.

DON'T SAVE LIGHT AT THE EXPENSE OF YOUR EYES.

Real and False Economy.

Saving light at the cost of eyesight is false economy. To get good lighting it is generally necessary to diffuse the light from the lamps either directly, by opal or ground glass shades, or indirectly, by turning the light first on the ceiling or wall. The use of ground glass in-

Fig. 14. Don't place a desk lamp like this; it glares from the paper and shines in your eyes.

volves the absorption of 15 to 20 per cent. of the light to secure diffusion, opal glass of various kinds from 20 to 40 per cent., while some forms of art glass and most diffusing ceilings absorb more than half the light that

Fig. 16. More light in the eyes than on the work and not enough light in the room. Sharp shadows and much glare from the polished metal. Discomfort to the worker, loss to his employer.

falls upon them. Even though all these appliances absorb light in the process of diffusion, there is gain in their use because they yield rays more grateful to the eyes. But your eyes may tire easily even with good

lighting. If so, consult an occulist and don glasses if you need them. Eye-strain often comes from defective eyes as well as from faulty lights.

Economy in Selecting Lamps.

In gas lighting there is no economy in using open flame burners unless the exposure is such that gas mantles would often be broken. Similarly, with electric

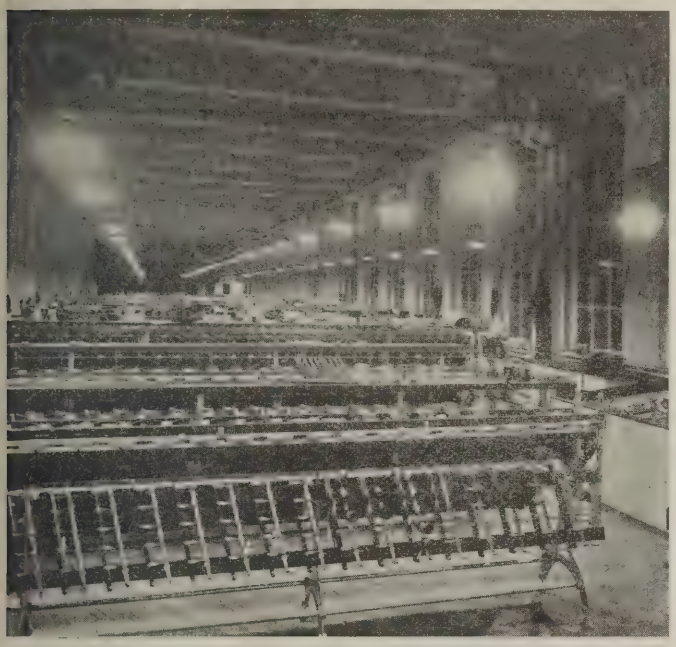


Fig. 1. Example of good illumination in a factory; the whole area is uniformly and brightly lighted.

lights it is very wasteful in most cases to use carbon filament lamps when tungsten lamps are available. The carbon lamps cost less to install or replace, but much more for electric current.[1]

Fig. 18. Each of these two little rooms received the same light. Dark walls absorb most of the rays of light in left-hand room.

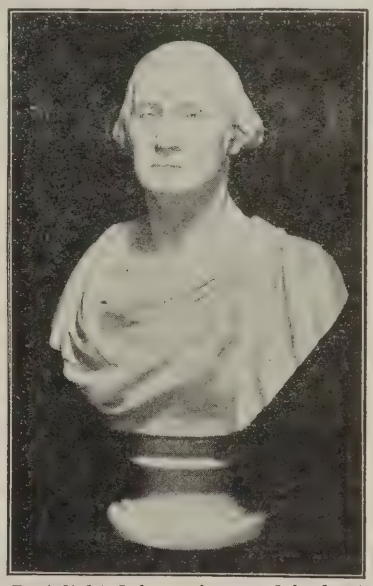
How to Figure Cost of Light.

[1]The amount of electricity taken by an electric lamp is expressed in watts. Most electric lamps now manufactured have the number of watts which they are rated to consume printed on a label on the bulb. The old-fashioned carbon filament incandescent lamp of 16 candle-power has the candle-power on the label, and takes from 50 to 60 watts.

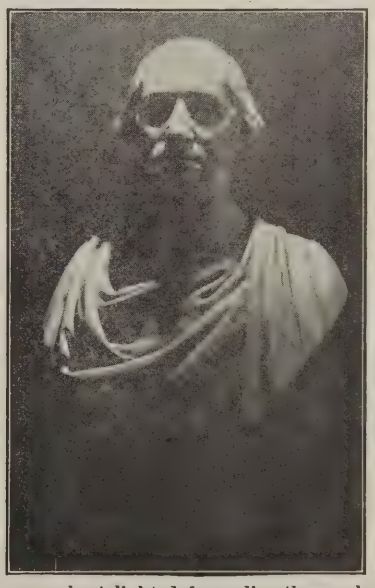
To determine the cost of operating an electric lamp, divide the number of watts it consumes by 1000 to reduce to kilowatts, and multiply the number of hours the lamp is to be operated by the kilowatts to obtain the kilowatt-hours of electrical energy. The kilowatt-hours multiplied by the rate per kilowatt-hour which is charged gives the cost of operation for the stated time.

The consumption of gas lamps is expressed in cubic feet of gas per hour. The number of cubic feet of gas per hour taken by a burner, divided by 1000, and multiplied by the cost per thousand cubic feet of gas, and by the hours of burning, gives its cost of operation for the stated time.

The consumption of open flame burners is commonly taken at 5 cubic feet per hour. Upright single mantle burners usually take from 3½ to 5 cubic feet per hour, though some smaller ones take less. Most individual inverted gas mantle burners take from 3 to 3½ cubic feet per hour.



Bust lighted from above and in front.



The same bust lighted from directly overhead.
Fig. 19. Bad Lighting Defeats good art.

AMOUNT OF ILLUMINATION REQUIRED.

The common unit of illumination is the foot-candle, meaning thereby the light which the object would receive from a standard candle at the distance of one foot. This is the measuring rod, as it were, by which comparisons are made.

No absolute rule can be laid down for the number of foot-candles required for good seeing. Individuals differ widely in their requirements; and the conditions under which the light is used cause still greater variations in requirement. However, where lighting arrangements are well planned it has been found by experience that ordinary reading, writing, or work on white or light col-

ored material, can comfortably be carried on by most people with an illumination of 2 to 3 foot-candles. For sewing dark goods, or reading fine type, 5 foot-candles are none too much, while for drafting, engraving, watchmaking, working on black cloth, and the like, from 7 to 10 foot-candles should be furnished.

Artistic Effects.

In a room suitably arranged for comfortable seeing, you may have plenty of light, but the general effect may be displeasing. The illumination may quite fail to bring out the good points of the room in architecture and decoration, or may play pranks with the appearance of persons or things in the room. (See fig. 19.) One may not object to ghastly tints in a factory, but in lighting a drawing room such effects would not be tolerated. Hence one often should sacrifice strict economy to get the most pleasing effect in the room. The fixtures that carry the lights should harmonize with their surroundings if the general effect is to be agreeable. Handsome fixtures have a decided decorative value whether their lamps are lighted or not. As strongly colored objects give something of their own hue to all the light which they reflect, the color of lamp shades, walls, and furnishings plays an important part in the artistic effect.

Ball Bearings for Axle Lighting Generators

W. L. Batt

EDITOR'S NOTE.
This is the first of a series of educational talks on the subject of ball bearings written by certain authorities on this subject who are connected with some of the various ball bearing manufacturers.

The problem of successful train lighting by electricity is chiefly a problem of maintenance. The conditions of service are extraordinarily severe, and the types of construction which have succeeded in stationary dynamos are difficult or impossible to apply.

Owing to the extreme belt tension, the bearings are subjected to pressures considerably above those considered safe in stationary practice. Due to the enormous amount of shock and vibration, conditions are imposed upon the bearings that are not met in any other service in which a generator is called upon to operate.

Plain bearings must be oiled daily, and even under the best conditions the oil film may be squeezed out by oversight in oiling or by an extra twist of the tightening screw, resulting in a cut bearing. Cut bearings, wasted oil, damaged armatures, and all their resultant trouble

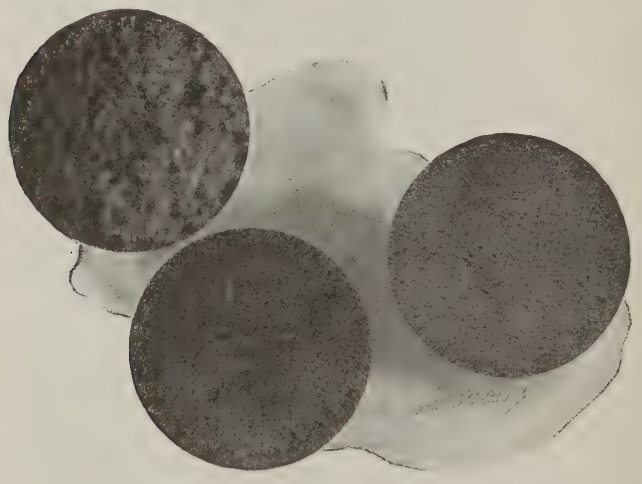


Fig. 1. Highly Magnified Ball Fractures Showing Different Qualities of Ball Steel. The Most Uniform is a Hess-Bright Ball.

and expense, are due to the inherent tendency of sliding bearings to wear away.

It must be remembered that a thin film of lubricant is the only element interposed between the rotating shaft and the fixed bearing. If this be even momentarily broken, the two surfaces under load, immediately come into contact. Reducing friction by special oils, etc., only palliates the fault. The basic cause, rubbing between two faces whose friction can only be reduced—never eliminated—still remains.

The modern method is to *eliminate* the friction that causes wear.

In a word, to substitute the *rolling* action of correctly designed and perfectly constructed ball bearings for the *rubbing* action of plain bearings.

The Problem of the Ball Bearing.

The crude conception of a rolling contact bearing appealed to inventors years before it was successfully embodied in practice. The difference in resistance between the "stoneboat" and the wheeled wagon, or between a safe dragged over the floor and one moved

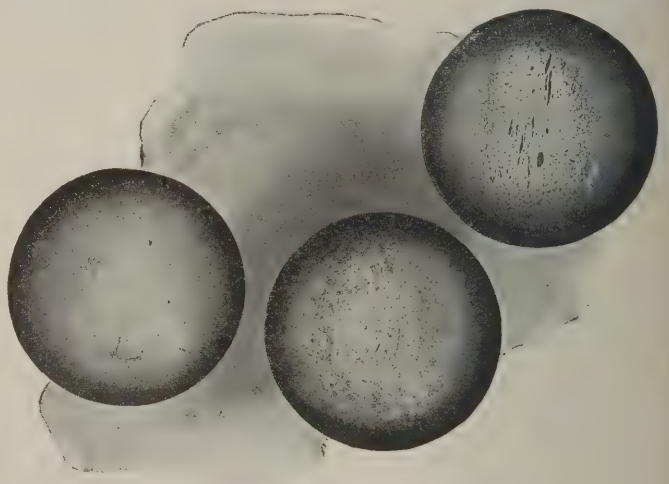


Fig. 2. Highly Magnified Ball Surfaces.

on rollers, finds a rough counterpart in the contrast between the friction of plain bearings and ball bearings.

But the practical application presented many difficulties. Early ball bearings wore out rapidly, for several reasons, none fully understood at first. Among these reasons was inaccuracy of form, which resulted in the load being supported by only one ball at a time. Another reason, which could not be overcome with the steel then in use, was the insufficient hardness of both balls and races. Still another was the failure to exclude dirt, which entered and acted as an abrasive to destroy rapidly both balls and races. A fourth reason was that the cup, and cone designs first employed, whether of the two, three or four point type, did not give the balls a pure rolling motion; there was always a spinning (and therefore rubbing) movement in addition. The familiar cup and cone bearings of bicycles and other light machinery, have been successful only because of the very light loads employed.

The Solution.

The whole subject of ball bearing performance and

design was studied exhaustively some eleven years ago by Professor Stribeck of the Neubabelsberg Technical Laboratories, at the instance of the Deutsche Waffen- und Munitionsfabriken, (the German factory in which Hess-Brights are made). Briefly stated, these tests, which extended over some years and cost a veritable fortune to make, showed that the condition of successful operation lay simply in the elimination of the usual factors of error, which till then had been deemed of no importance.

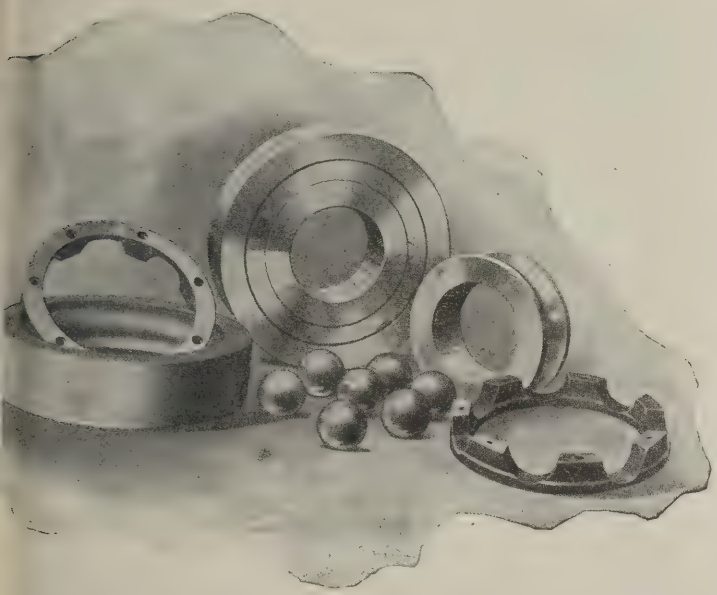


Fig. 3. Parts of a Hess-Bright Bearing, Balls 1.1/16 in. Diameter.

One of Stribeck's findings that completely reversed previously established theory was the relatively high carrying capacity and low friction of ball bearings as compared with the roller. Prior to the knowledge gained from these tests, differences in the two were predicated upon the theory of a line and a point contact, assuming that there was a pure rolling action in both cases. But pure rolling is a theoretical possibility merely, requiring for its realization absolutely true shapes initially, and inelastic materials that will not change shape under load. A series of rollers that are truly cylindrical and alike as to diameter, also a cylindrical shaft for them to roll on and a true cylindrical box for them to roll in, within the requisite small limits of error, is very difficult to produce commercially. More serious still is the fact that under heavy loads such accuracy as may be had is largely defeated by the deflections of machine framing. This causes the rollers to skew more or less, and it follows that the theoretical long line contact of the rollers does not exist in fact, but is limited to a small fraction of the roll length. The tests showed increasing power consumption as rolls were long and decreasing as rolls were short.

Difficult as the production of a perfect ball is under ordinary shop conditions, specialists can deliver balls that are true spheres to within one ten-thousandth part of an inch, at relatively small cost. This led to attempts to employ a series of rows of balls instead of rollers. After an endless number of expedients to provide for proper load distribution had been tried without success, the simple plan of using a single row of balls and that of suitable proportion for the load was adopted. This resulted in a journal having no appreciable length and accordingly free from trouble caused by deflection. The problem was then to proportion the diameter and the number of balls to the load to be carried. As the number of balls in a single circle was necessarily limited and as the journal diameter could not be indefinitely increased, it became important to develop the carrying capacity as affected by the shape of the ball tracks and the nature of the materials.

Fig. 4. Atlantic City & Shore R. R. Ball Bearing Main Journals in Service Four Years.

A wide range of experiments on various shapes of ball tracks proved that a flat ball track would carry only about 1/3 the load sustained by a track which had a very decided curvature with respect to the ball. That is the reason why the Hess-Bright Ball Bearing for axle generators, with a groove encircling one-quarter of the surface of the ball, can successfully meet severe railway conditions. In addition, these deep ball grooves give an unusual end thrust capacity.

It may be safely said that only the recent advent of high-grade alloy steels has made the ball bearing possible as a heavy load bearing machine element. Fortunately the DWF (translate "German Small Arms and Ammunition Factories") counted among its various subsidiary plants two of the world's leading tool steel works. This greatly facilitated the development of the needed special alloy steel, and explains why the unusual toughness and hardness of Hess-Bright bearings can be so consistently maintained.

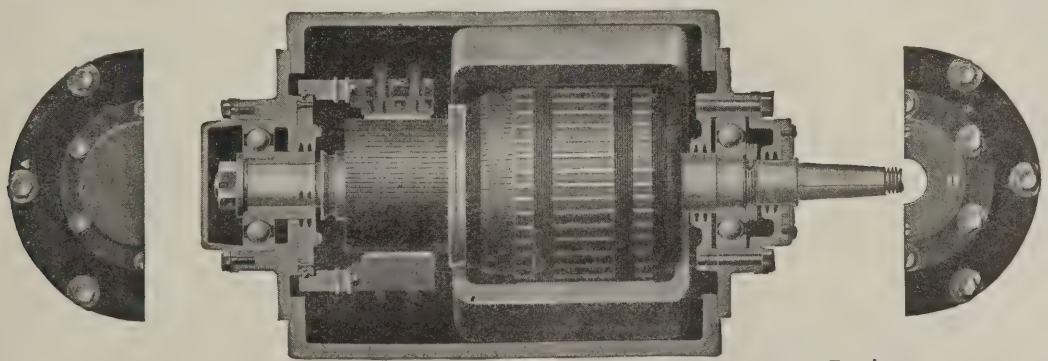


Fig. 5. Sectional View of Car Lighting Generator Showing Ball Bearings.

Practical Applications.

The success of the application of Hess-Bright Ball Bearings to axle generators is assured, because of the wide service to which those bearings have been put in other and similar service. For four years they have been used on railway and mining motors, from the smallest motors up to those of 140 H. P. and with unparalleled results.

The largest manufacturer of mining locomotives in the world has adopted them as standard for motor construction and in four years' experience, covering thousands of motors, ball bearing failures can be counted on the fingers of one hand. That they have satisfactorily met the rigorous demands of mining service in such manner is evidence that they may be thoroughly depended upon for axle generator service. They are being regularly used by scores of manufacturers of heavy duty machinery, and such has been the success regularly attending their use, that a Hess-Bright Bearing is by very many users considered the resort when all other types of bearings have failed.

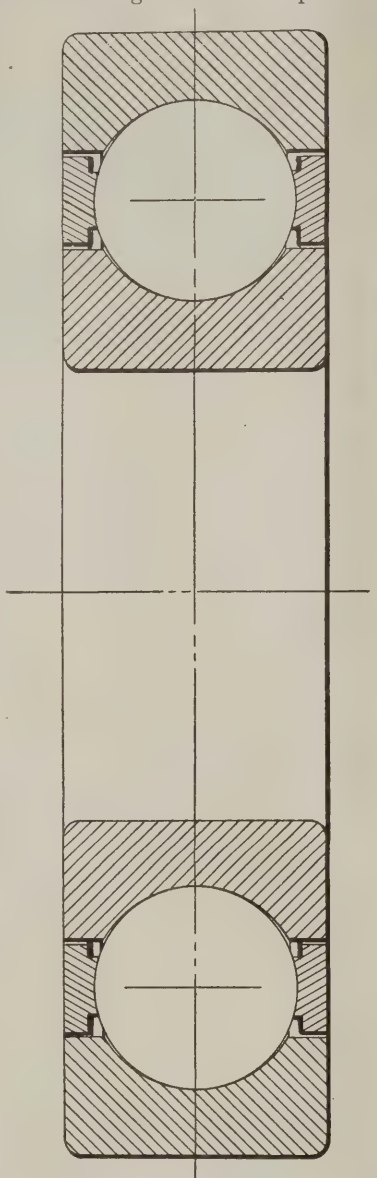


Fig. 6. Sectional Drg. of 7412 Bearing as used on Axle Generators. (This diagram is full size.)

Method of Application.

The manner in which ball bearings are applied to axle generators is shown on the above cut. Two bearings are used on each generator; the one on the commutator end being confined as to its outside race to take the end thrust. The deep race groove of the Hess-Bright Ball Bearing gives it unusual capacity for resisting end shock, of which there is so much in this service, due to the side surge of the armature in rounding curves. The size of bearing is No. 7412, the ball diameter being 1 1/16". Each of these balls has a crushing load of 90,000 lbs. The separator used in this type of bearing is made from manganese bronze, in two half sections, rivetted together. This construction is such that every ball could be crushed or removed from the bearing and the separator would be sufficient to carry the armature for some time and to prevent it from dropping on the pole pieces. Ball failure is so unusual as to be negligible, but provision is thus made for insurance against it. The grooves in which the balls roll have a greater radius than that of the ball and therefore considerable tilting is permitted in the bearing without in any way impeding its free rolling action. The possible amount of shaft deflection is about 1/16" to the foot. This is evidently far more than could ever be required on an axle generator bearing.

The housing around the bearing is designed to hold grease. The retention of this in the box is provided for by the lip and groove closure at the points of shaft entry. Evidently the frequency with which lubricant must be

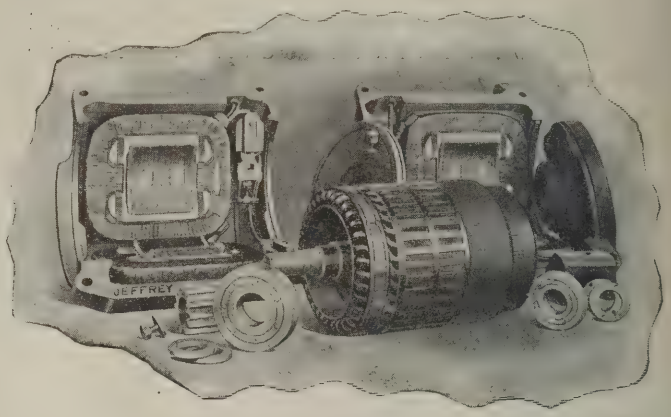


Fig. 7. Parts of an Axle Generator with Ball Bearings Ready for Assembling.

supplied entirely on the efficacy of its retention in the housing. With the ordinary grease it will usually be found necessary to lubricate about every two months and the housing should not be filled entirely full of grease at this time. The grease used must be free of acid or alkali, in order that it shall not pit the finely polished surfaces of the bearings. It should be fairly soft and should hold its body up to a temperature of at least 150° Fahrenheit; it should not pound thin in service. In the event of question as to a grease, temporary use may always be made of vaseline, although this will pound thin in service. The grease may be applied by some form of grease gun through the 3/8" diameter nipple provided in the housing. Approximately 1/4 lb. of grease will be necessary with the average machine at a charge, every two months. A ready comparison of the savings possible in lubrication alone may be made, considering that the average generator on plain bearings must be lubricated seven to twelve times per month.

THE NEW NORTHWESTERN LIMITED.

On November 15th, the C. & N. W. Ry. placed a new train in service, the new Northwestern Limited. This train runs regularly between Chicago and St. Paul, and as regularly made up, consists of a baggage car, a standard coach, one end of which containing accommodations for 24 persons has been partitioned off as a smoker; a chair car; a diner; a lounging car; a standard 16-section sleeper; a standard sleeper containing ten sections, two compartments and a drawing room; a third sleeper containing 14 sections and one compartment; and the observation-compartment car at the rear, making nine cars in all.

The Pullman equipment of the train is of all steel construction while the remaining cars are remodeled Northwestern equipment having steel underframe construction, steel sheathing and wood interior finish.

A special feature of the train is found in the lounging car, which was rebuilt at the company's shops and embodies several entirely original features designed for the comfort and convenience of the passengers. This is divided into two main compartments, the library and buffet parlors, respectively, between which is the steward's larder. These compartments are luxuriously furnished and have a distinct aspect of home, not found in the usual passenger car.

SHOP SECTION
EDITED BY
GEO. W. CRAVENS

Motor Talk No. 3

SERIES WOUND MOTORS.

Series wound direct current motors are usually made for operation on circuits of constant voltage, and are so connected internally that the current passes through both the field and armature windings in series. The

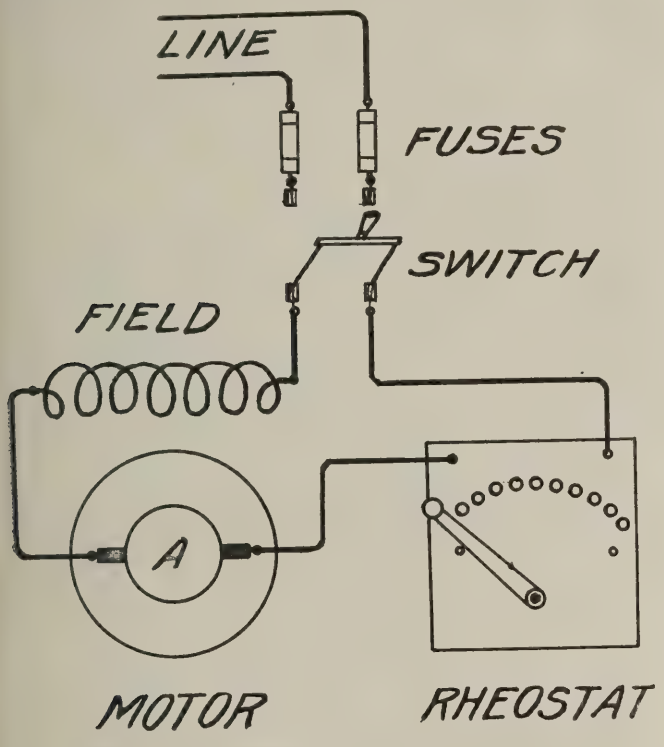


Fig. 11. Connections for Series Motor and Rheostat.

largest field of application of these motors is for railway purposes, but they are also used in considerable numbers for hoists, cranes, etc., and in other cases where variable speed motors with powerful starting torque are required.

The windings on the fields of series motors are of large cross section in order to carry as much current as the armature, and both field and armature windings are made with as low resistance as possible in order to keep down the watts lost in them. By having small resistance in the armature windings we also get better speed regulation. One of the principal points of difference between series and shunt motors is that shunt motors run at practically constant speed regardless of load, whereas, series motors vary greatly in speed with load variations. The speed falls off as the load comes on, and rises when the load is reduced.

When the motor is running light the energy taken from the line will be just enough to enable the motor to overcome the internal losses, such as friction, core losses, etc. As the armature speed increases there will be an increase in the counter E. M. F. and the current will decrease. (This action was explained in the first article of this series.) But, the field coils are in series with the armature windings, so the field strength will be reduced by the reduction of current flowing and the armature must run faster in order to generate the same counter E. M. F. as before. The result is that there is a tendency for series motors to run away under a very light

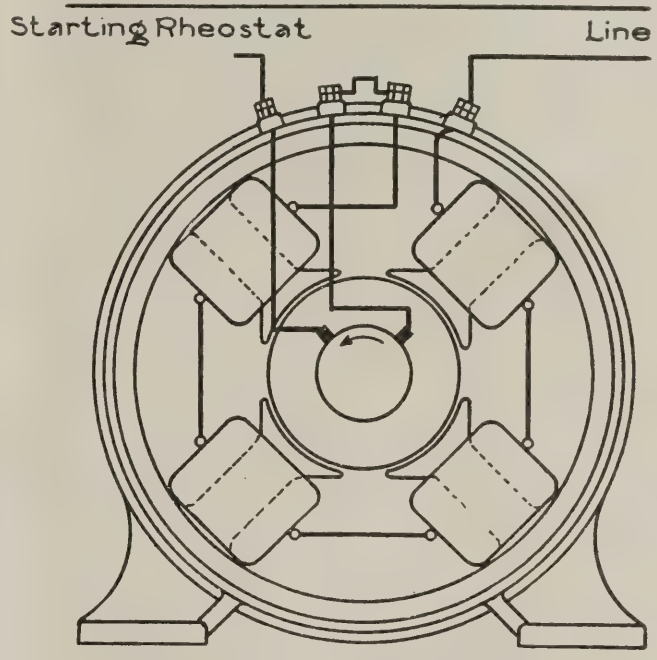
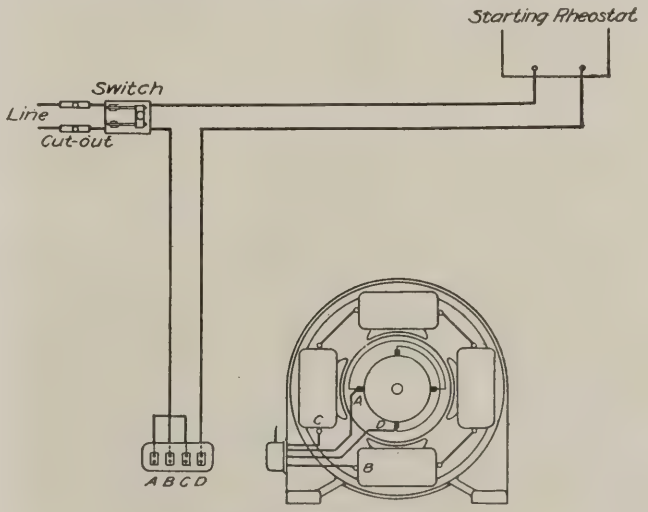


Fig. 12. Connections for 4-pole Series Motor.

load or with no load at all. That is why they are only safe where always under control of the operator.

When operating under load the counter E. M. F. decreases a little because of the reduced speed, and this allows more current to flow, strengthens the field and



A and D are Armature Terminals
B and C are Field Terminals

Motor connected for Counter Clockwise Rotation. For Clockwise Rotation change external connection from B to C and connect A to B at the Terminal Block

Fig. 13. Four Pole Series Motor with Connection Board.

increases the torque. The torque of a series motor is dependent upon the amount of current flowing through it, because the field strength varies with the current instead of being independent of armature current as with shunt motors. A strong starting torque can be produced

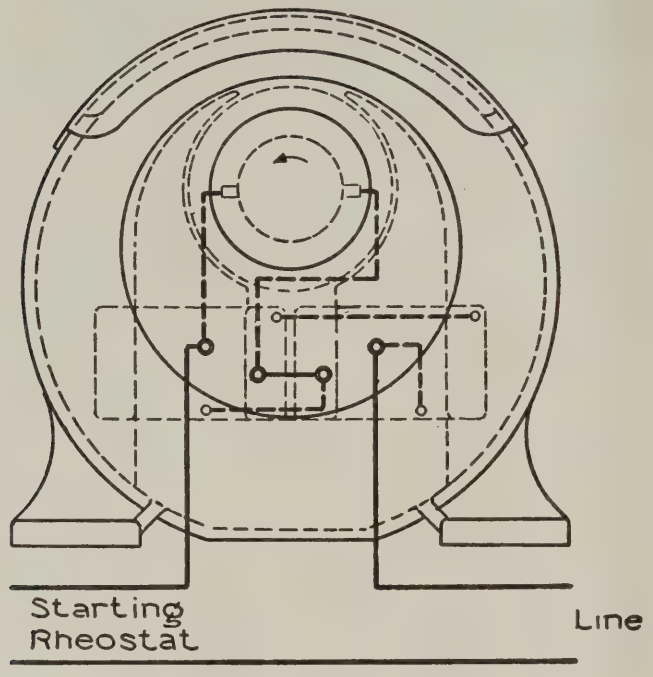


Fig. 13. Connections for Bi-Polar Series Motor.

by allowing a large amount of current to pass, thus making the series motor especially good for hoists and railway service. There will however, be a different speed for each load because the field strength increases as the load is applied and drops off with load.

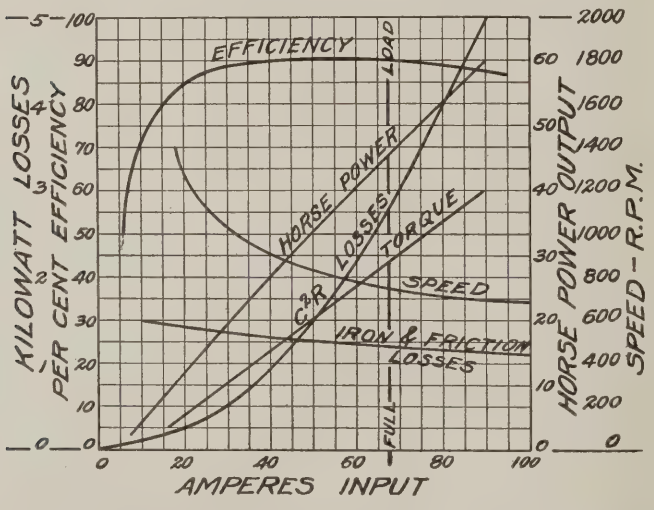


Fig. 15. Characteristic Curves for 45 h. p. 750 r. p. m. Seriees Railway Type Motor.

Since the field coils are made of comparatively heavy wire, and of few turns, series motors cost less to build than shunt or compound motors, and are less liable to be burned out in service. On the other hand, speed control is obtained usually through the addition of large capacity and comparatively expensive series resistances, although it is possible to get good speed variation through varying the number of turns in the fields. A variable shunt in parallel with the field is also used at times. Where two or motors are used on the same machine, such as on street cars, the custom is to use resistances and to connect the motors in series or parallel to vary the speed. This is an economical way of doing it, but cannot be used to good advantage with single motors except by varying the field connections (series and parallel) as is sometimes done on automobiles.

The Question Box.

Editor Shop Motor Section:—

In a text book I have been studying there is a problem in motor design I cannot work, and I would like to have you answer it in your paper so some of the other boys can see how it is done.

This motor is supposed to have an armature resistance of .25 ohm and a field resistance of .15 ohm with a friction loss of 380 watts. The armature contains 900 turns and the total magnetic flux is supposed to be two million through the armature. It is a series motor.

With this data we are supposed to tell what the armature speed and brake horse power will be with 20 amperes flowing if the motor is connected to a 400 volt circuit. We have never had any series motors here and I do not know how to go about it, so won't you please tell me.

K. L. M.

Answer—The total loss of volts in the machine will be equal to the total ohms X the current, or 20 x (.25 x .15) = 8 volts. Taking this from the line voltage, 400 — 8 = 392 volts left to overcome the counter E. M. F., of the motor when running. To produce this C. E. M. F., the speed will have to be equal to the quotient obtained by dividing the product of the volts (392) times one hundred million by the number of turns times two million. As a formula, this will be $n = 392 \times 100{,}000{,}000 \div 900 \times 2 \times 1{,}000{,}000 = 21.8$ revolutions per second, or 1308 R. P. M.

The total rate of doing mechanical work is 392 x 20 = 7840 watts of which the friction loss is 380 watts leaving 7460 watts or 10 H. P. at the brake. (746 watts = 1 electrical horse power).

G. W. C.

NEW BOOK ON CAR LIGHTING.

Dr. Max Buttner, of Berlin, has just completed a most comprehensive treatise on the subject of car lighting in England, Continental Europe, America and India. The book takes up candle, oil and gas lighting and describes briefly the various systems now in use. It then goes into the subject of electric car lighting very extensively, and describes practically all of the various systems which are in use at the present time.

It is written in German so this book may not be available to many of us in its present form. Various parts of it, however, will be translated from time to time and given in connection with the A. B. Car Lighting Lessons as published in the *Railway Electrical Engineer*.

The book may be procured from Julius Springer, Publisher, Berlin, Germany, W. 9 Linkstrasse 23-24.

It sells at 6 marks, $1.50.

EDISON STORAGE BATTERY DATA BOOK.

The Edison Storage Battery Co., of Orange, N. J., have just issued a data book giving blue prints of curves showing operating characteristics of the Edison Storage Battery. A flexible leather binding is provided with the data book and additional sheets will be supplied by the Edison Company from time to time for this book. This data book has been distributed gratis to railroad men directly in charge of railway car lighting matters.

Lesson No. 10

Axle Lighting

THE BLISS-BUCKER SYSTEM.

Of all the car lighting devices ever devised, the system of control developed by Mr. W. L. Bliss, known as the "Bliss Bucker," is one of the most interesting from a student's standpoint. Experience has shown however, that this equipment seems to have been a bit too complicated for effective service for there are few of them that are still in service. But this equipment, contains many unusual features, and we as students of car lighting methods and devices should be well informed on this subject.

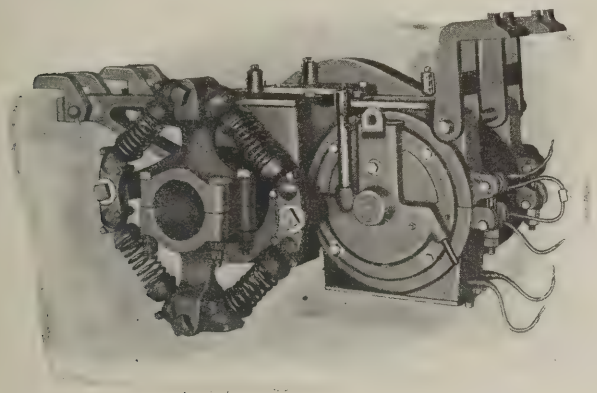


Fig. 46. Bliss Geneerator With Spring Gear Drive.

The Generator Drive.

The equipment as originally designed had a spiral spring gear drive combination as shown in the accompanying illustrations, Figure 46. A two armed dog was clamped solidly to the car axle and a split quill with a large gear at one end and two dogs at the other, was driven by means of four springs connecting to the axle dogs. This whole quill ran in a roller bearing, and the

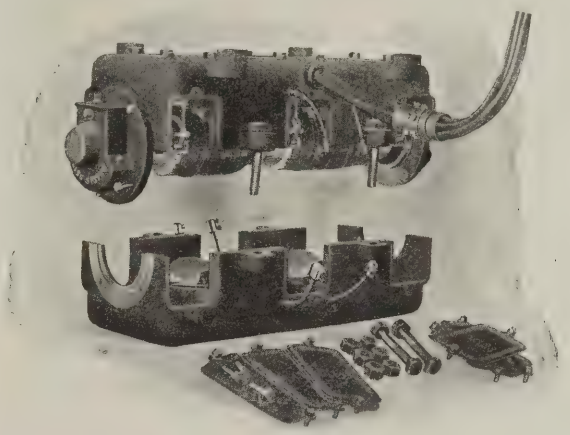


Fig. 47. Bucker with Lower Half of Housing Removed.

large gear meshed with a pinion on the armature shaft of the generator. As is at once evident, this outfit was cumbersome to install and maintain and absorbed a large amount of power from the generator axle. In the later types of "Bucker" equipment this spring gear drive was supplanted by the belt drive as used on most of the car lighting generators today.

The Bucker.

It is in regard to the bucker principle, however, that this equipment is of particular interest. The bucker consists essentially of a little motor generator set, the generator armature of which has two entirely separate and distinct windings. One of these windings has a compa-

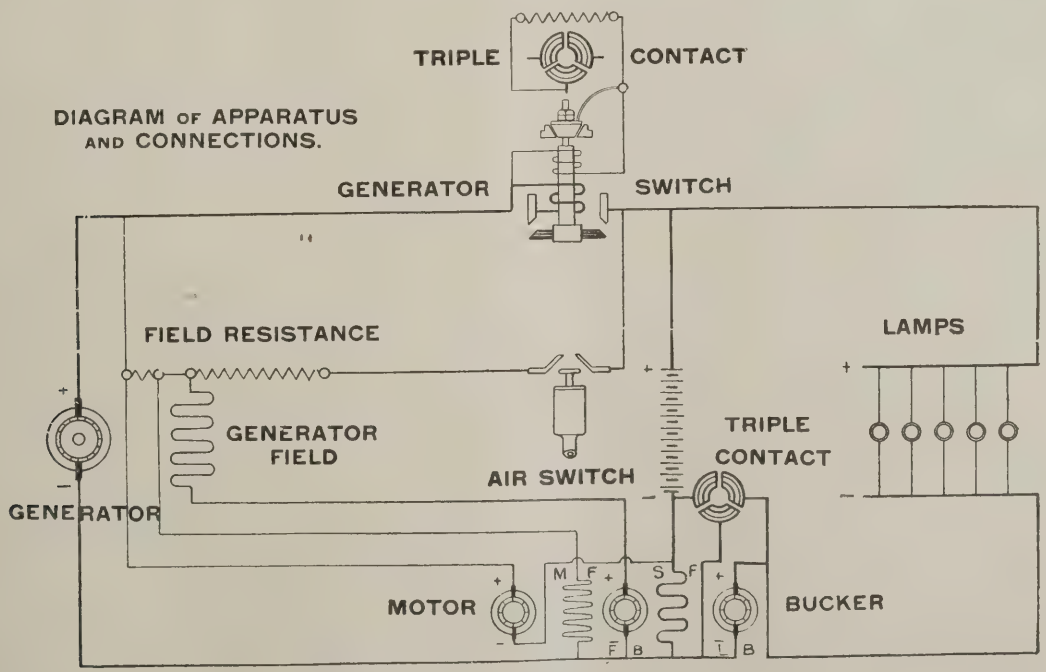


Fig. 48. Wiring Diagram, Bliss-Bucker System of Car Lighting.

ratively large number of coils, and is placed in series with the generator field, this is known as the "field bucker." The other has a few coils of heavy wire and is placed in series with the lamp circuit, this is called the "lamp bucker." The field winding of the bucker is of heavy wire and this is placed in series with storage battery, as shown in the accompanying diagram, Fig. 48.

As the generator picks up and the automatic switch closes, the bucker armature will be driven at full speed by its own motor. Then, as the train speed rises further a charging current will begin to flow into the battery, but this passes through the series field of the bucker and generates an electro motive force in the coils of the field bucker which opposes the flow of current through the generator fields. This cuts down the generator field slightly and reduces the voltage nearly to normal value.

Auto Switch.

As the train speed rises higher, the generator voltage will tend to increase still further and will cause a higher battery charging current to flow. This in turn will produce a stronger field bucker voltage and cut the generator field current down still further, again bringing the generator voltage back to practically normal value. There is actually a slight rise in generator voltage, however, for at the higher speeds there must be a heavier charging current flow to effect proper field bucker strength; this may require a rise in generator voltage of 6 or 8 volts to force this higher current flow through the battery.

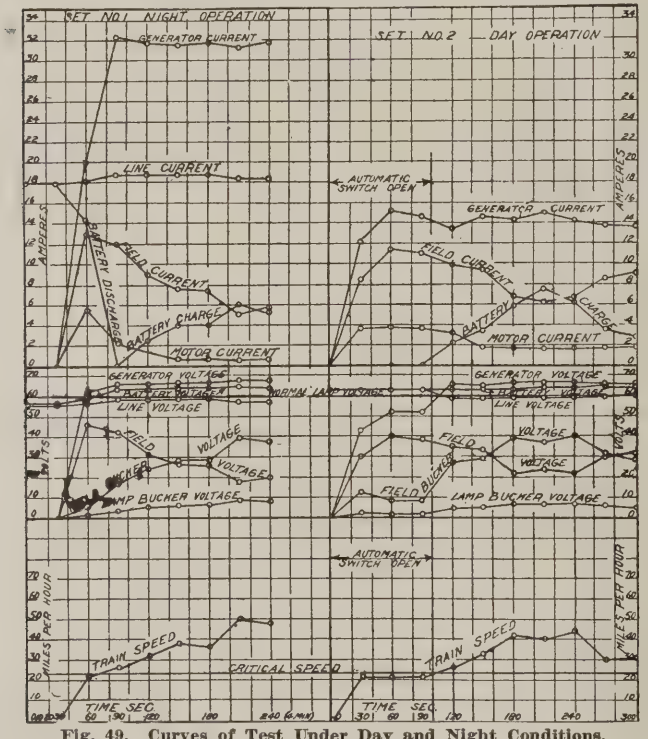


Fig. 49. Curves of Test Under Day and Night Conditions.

The writer made an extensive test in 1906 of a car equipped with this system on the Northern Pacific between St. Paul and Portland. Figs. 49 and 50 show some typical curves of the operation of the equipment.

It is seen from these curves that with a train speed of 20 miles per hour, which is just about cutting in speed, the generator voltage was at 62 volts, the field bucker voltage 5 volts and the generator field current 13 amp. When the train speed got up to 31 m. p. h., however, the generator had increased to 65 volts, field bucker to 25 volts, and this bucking voltage in the field circuit had reduced the field current down to 8½ amperes. At a still higher train speed of 50 miles, the generator voltage had risen to 68 volts, the field bucker voltage to 39 volts and the generator field current had been reduced down to 5 amperes.

Lamp Bucker.

As stated above, there is a definite rise in generator voltage which is proportional to the rise in train speed above critical speed, so in order to compensate for this variation in voltage and provide constant voltage on the lamps, the lamp bucker was designed.

The windings of the lamp bucker armature are on the same core with the field bucker armature, and receive the same magnetising strength and operate in the same magnetic field which is generated by the battery charging current. As there are a comparatively small number of turns in the lamp bucker winding, it will develop but a few volts, but this will be at all times proportional to the field bucker voltage.

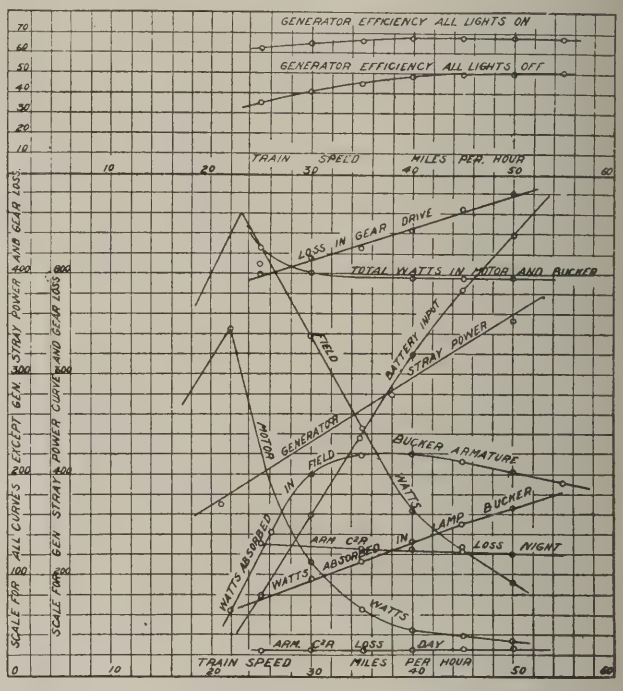


Fig. 50. Curves Showing Power Absorbed in the Various Parts of the Bliss Bucker System.

It is seen from the curves, Fig. 49, that 20 miles per hour, which is the cutting in speed, the lamp bucker was developing only about 1 volt, while at 30 miles per it was developing 6 volts, and at 50 miles per hour 10 volts.

This lamp bucker is placed in the lamp circuit but its voltage opposes the flow of lamp current supplied by the generator and at the 50 mile speed when it is generating a bucking voltage of 10 volts, it reduces the generator voltage from 68 volts to 58 volts, which is about normal value.

It is evident that with a lamp bucker, where it is simply a question of voltage, the regulation will be entirely independent of the number of lamps that are lighted, and it will also automatically compensate for the rise in generator voltage at the higher train speeds. When the generator is not operating the "Triple Contact" on the automatic switch short-circuits the lamp bucker armature.

With this system the generator takes care of any lamp load that may be required and charges the storage battery entirely independently. In the day time, when the lamps are turned off, the generator current is simply reduced by that amount, and is just high enough to develop field current, battery charging current and drive the bucker motor. This point will be observed by comparing the left half of Fig. 49 which is under night operation

with the right hand column of curves which is for day operation. This lamp bucker, however, does not give any absolute regulation of lamp voltage as may be obtained with some of our modern lamp regulators. It should be noted that the lamp voltage is the difference between the generator voltage and the lamp bucker voltage. Now, as the batteries become charged, they will require a higher voltage to force a definite charging current to flow, but as the lamp bucker voltage for any certain train speed remains about the same, the lamp voltage with a battery nearly charged will be considerably higher than under the same train speed with a battery of low charge.

The curves of Fig. 50 showing the variation in power absorbed in various parts of this axle equipment, will be found of interest. The curves are plotted with train speed horizontally and watts and generator efficiency vertically.

It should be noticed that the power used up in the generator field circuit rapidly falls off from 460 watts at 23 miles to 90 watts at 50 miles, and the power consumed by the motor which drives the bucker also falls off rapidly from 350 watts down to 35 watts. This latter point may seem strange, but at the higher speeds, both the field bucker and the lamp bucker act as a motor and help drive the bucker. The total watts of the motor and bucker as shown in these curves remains constant at about 400 watts.

The power taken to drive the split sleeve gear drive arrangement is shown to vary from 800 watts (1 h. p.) at 23 miles to 9600 watts (1¼ h. p.) at 50 miles. The generator stray power is also excessively high. These two latter items undoubtedly account for the low efficiencies under day and night operation.

One of the most interesting of this set of curves is the battery input curve which shows the way battery charge rises with train speed. This is expressed in watts, but can easily be reduced to amperes by dividing by 60 for an approximate figure. This starts from 0 at 20 miles per hour and increased almost directly with the increase in speed above that point.

Setting the Regulator.

As stated above the battery is charged at all times while the train is above cutting in speed entirely, independently of the number of lamps that are lighted. This charge varies however, from one ampere, just above cutting in speed, to 7 or 8 amperes at about 50 miles per hour. An adjustable shunt across the bucker series field windings makes it impossible to shunt more or less of the battery charging current away from the bucker. Or in other words, increase the battery charge by the amount of current shunted.

To set this regulator at the proper value, the average speed of the train must be known. This can be easily obtained, however, from the train schedule. Then knowing the number of hours the generator will be in operation on each run, the charging current can be adjusted *at the average train speed* so as to provide a charge in ampere hours about 50% greater than the average discharge at the stops.

Example.

If the train covers 350 miles in 11 hours, one hour of which is spent at stations and stops, etc., it will make an average speed of 35 miles. If the lighting during these stops aggregates 1 hour, and the terminal lighting 3 hrs. the total discharge amounts to 10 amp. for 4 hours or a total of 40 amp. hrs. (60 volt equipment). This, increased 50% to allow for battery inefficiency, and for emergencies makes 60 amp. hours, which on a basis of the generator operating 10 hours would require a setting of 6 amperes when the train is at the average speed of 35 miles.

The January lesson will be on the Everett Regulator.

Head End System.

SYSTEM IN USE ON HARRIMAN LINES.

The main difference between the headend system of the Harriman lines and that of other roads is that in charging, the battery is cut in two, and the two halves, being of but half the voltage of the whole battery, are then charged in parallel to full capacity without raising the line voltage at all. As a matter of fact an iron grid resistance must be placed in circuit to prevent the charging current going too high at the beginning of charge. The switchboard and wiring connections are clearly shown in the wiring diagram and view of switchboard. It should be noted however that two double pole circuit breakers are provided. One for the battery circuit and one for the generator circuit. A volt meter contact switch makes it possible to read the voltage of either a

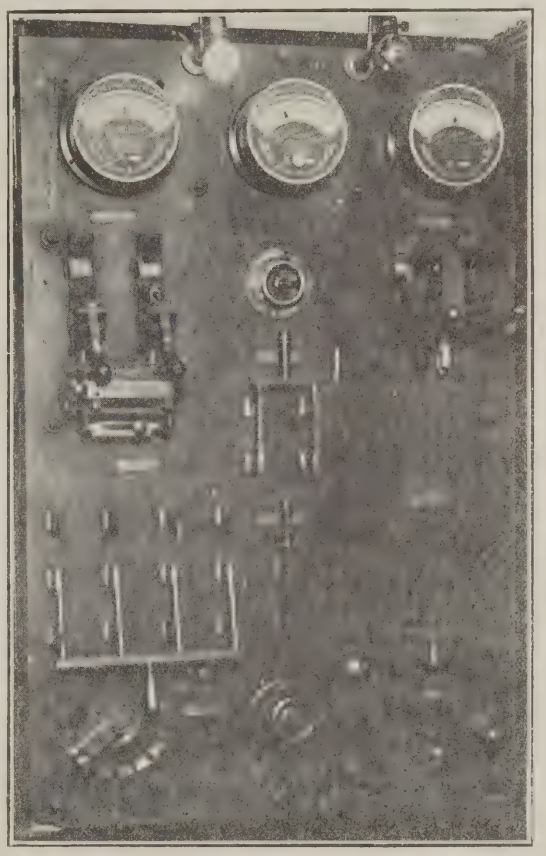


Fig. 51. Switchboard of Union Pacific Cars with Segment Contacts for Charging Resistance.

half battery, total battery, generator, busbar, train line, positive to ground and negative to ground.

Some of the Harriman lines having two sets of circular segment contacts with a handle which can be twisted in cutting in or out resistance grids, instead of closing or opening resistance circuits with knife blade contacts as employed on the Northwestern.

One resistance is placed in each battery circuit and each battery charging current can be adjusted independently of the other in the U. Pac. system.

The battery is charged about midnight when the lamp load is low and to do this the battery switch is thrown into the charge position. It takes 2.5 volts per cell to charge a battery to full capacity and while train line voltage of 64 would not be sufficient to fully charge 32 cells of battery in series, when the battery switch is thrown to the charging position the battery is cut into

two parts of 16 cells each. This at 2 volts per cell makes them but 32 volt batteries, so they can easily be charged with the standard lamp voltage of 64 volts.

On account of the low voltage of the half battery, it is necessary to insert an iron grid resistance in series with the batteries to keep the charging current from rising to such a high value that it might buckle the battery plates or overload the generator. The grids of this resistance are short circuited one by one by closing the single knife switches shown at the bottom of the board, so that as the charge proceeds and the current tends to fall off, it may be boosted by cutting out this resistance and raising the impressed voltage on the battery.

The instructions given train men regarding charging are to charge each half battery at 30 amperes, (60 amperes for the two half batteries on the dynamo car and 60 amperes for the two half batteries on the observation car), until the battery charging voltage raises to 40 volts for each half battery. In warm weather however, it may be found that battery voltage will never get as high as 40 volts, in fact, it may not go above 37 volts. It should be noted however, that the battery voltage rises slowly on charge and finally reaches a maximum, usually about 40 volts and then doesn't rise above that maximum. The charge should be continued until two successive readings of voltage at least 15 minutes apart show the same indication, but be sure the charging current is kept up to 60 amperes for each battery.

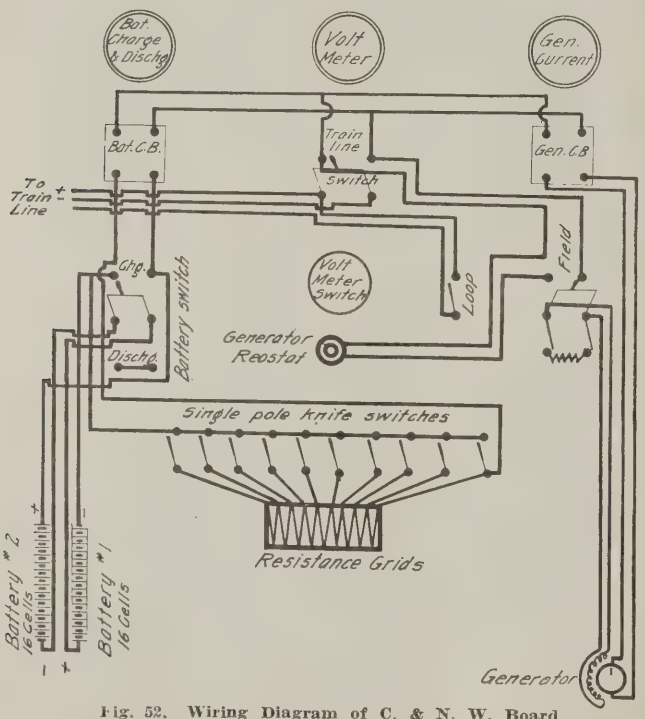


Fig. 52. Wiring Diagram of C. & N. W. Board.

In opening a generator field circuit it is well known that there is always a big spark. This is caused by the fact that when the generator field is up to full strength there is a large amount of energy stored up in that field. When you open the circuit this energy must come out of that field pretty sudden, and in doing this it actually boosts its own discharge voltage up to several hundred volts for a small fraction of a second. This is why men sometimes get a pretty severe "kick" when a field circuit is broken even with a 30 or 60 volt system.

This arcing which usually occurs on opening a field switch tends to burn the knife contacts, so on this board there are two lower contacts on the field switch with an elbow extension of the switch knives below, which, just as soon as the knife blades leave the upper contacts, they are connected to the lower ones. There is a resistance short circuiting these two lower knife blades, and when the switch is opened, instead of producing a fat spark, the energy stored up in the generator field it is dissipated by a discharge current flowing through this resistance for a fraction of a second. This is merely a small detail not entirely necessary but which keeps the field switch from being burned by arcing.

One of the troubles with the Northwestern system is that if one or more cells in a half battery become slightly sulphated due to grounds or short circuits, the voltage of that half battery containing these sulphated cells will rise more rapidly than the other half battery when they are placed on charge. The result of this will be that the

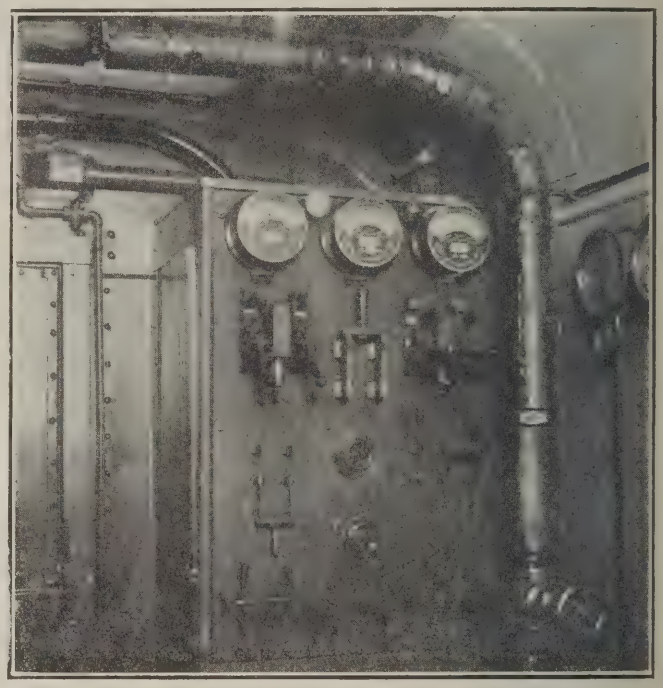


Fig. 53. Generator Switchboard, C. & N. W. Ry., with Knife Switch Contacts for Cutting in or Out Charging Resistance.

half battery which is in bad condition will receive less charge than the other half which is in normal condition.

Now, when a battery becomes sulphated the thing to do to cure the trouble is to break up that sulphate by a long vigorous charge. If the battery is left in a half charged condition it will sulphate still further and go from bad to worse.

But to get back to our train lighting battery; the half battery which is in good condition will receive a full charge while the other half with the sulphated plates will not, and at the end of charge the one half will be up to full capacity and show normal voltage when tested with a lamp load, while the other half will be somewhat below normal and will be run in an undercharged condition. This will cause the cells which are in trouble to sulphate further and on the next change even a more unbalanced condition will exist. It is obvious that this is one of the troubles which must be very carefully guarded against when batteries are being charged in parallel as in this system.

Another thing to be careful of is overcharge. When you have a voltage of 64 volts available for charging a 16 cell battery, this is fully 20 volts higher than will ever be required to bring those half batteries up to full capacity, and the tendency will be for the electrician to "give'er enough juice to last a while" by short circuiting more of the grid resistance than is actually needed at the time and then proceed to take a rest and forget about his battery on charge.

The battery should be watched very carefully at about the end of charge. Some times it may take only two or three hours charging, and other times it may take eight or ten hours charging to bring the battery up to full capacity. It depends upon what discharge the battery has had while laying in the station or in the yards, or at engine changes, etc. The electrician can usually tell in a general way what the condition of the battery is by the voltage on charge. Readings of voltage should be taken every 15 minutes near the end of charge, and in warm weather if you get two or three consecutive readings of about 37 or 38 volts, or in modern weather 40 volts, or in the coldest weather 40 to 45 volts it is safe to assume that the battery is fully charged and the charge may be then discontinued.

Next month's lesson to be on the B. & O. system.

RAILWAY CONDULETS.

Condulets for railway cars, shops, round houses and yards were shown at the recent convention of Railway Electrical Engineers, in Chicago. The designs included types for practically every wiring requirement not already provided for by older forms of Condulets, and being exhibited here for the first time, they attracted much attention. In all about thirty different styles were shown, as well as special receptacles and plugs for use with individual types. From among these we have chosen those illustrated below as exemplifying the force of the Crouse-Hinds slogan "A separate type for every requirement."

Type MD Condulet provides a mechanical means for connecting and disconnecting the wires leading from the dynamo to the regulator in the car. It is in two principal parts: A female section, which acts as a receptacle, and

Fig. 1. Type M. D. Condulet in Closed Position.

a male section, which acts as a plug. The female portion contains the contacts, and is fastened underneath the car, in the same manner as the wooden terminal blocks heretofore used for this purpose. The male, or plug portion, is attached to the cables leading from the dynamo. The plug is inserted in the receptacle by means of a lever which insures positive contact between the contact parts. This contact cannot be broken except by operating the lever. The lever is provided with a device to lock it into the closed position.

The contacts are the knife-blade type, 200 amperes capacity, and so designed as to insure perfect contact at all times. They are well protected from the weather, dust and dirt, and all current carrying parts are thoroughly insulated. Ample room is provided in the condulet for making all connections. The whole device is substantially constructed, to withstand the severe usage to which it is subjected in railroad work.

One of the principal advantages of type MD condulet is that it prevents incorrect connections being made when trucks are replaced after having been removed from the car for repairs. Another feature is that the electrical connections between the dynamo and the regulator can be instantly disconnected without the use of tools or the removing of parts which might become lost. Connections can be made or broken by car men, without the services of an electrician, thereby saving time and labor. Provision is also made for securing to the condulet the cable covering which protects the dynamo wires. In brief, type MD condulet is a labor saving and fool-proof connecting and disconnecting device.

Type RS condulet is the trade name of a rectangular junction box with removable top and open sides. Single hub plates, two-hub plates or blank metal plates, which last can be drilled and tapped for conduit as desired, are

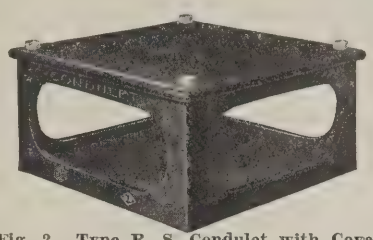


Fig. 2. Type R. S. Condulet with Cover.

provided for the open sides. Cover and side plates alike are fitted with gaskets which make the joints water-tight. Hexagon head machine screws are used to fasten cover and side plates in position. Type RS condulet measures ½ inches long and 4 inches deep. One-hub and two-hub side plates are made with holes tapped for

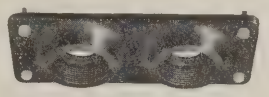


Fig. 3. Two Hole Side Plate.

all sizes of conduit from ½ to 2 inches, inclusive, as specified. As these side plates are interchangeable, practically any desired combination for conduit openings can be secured.

Another feature of type RS condulet that recommends it strongly is that there is no loss of fittings resulting from the cracking of the box while being drilled for conduit, as frequently occurs where one-piece boxes are used.

Yard charging condulet, type UGC, consists primarily of two parts—upper and lower. The upper part acts as a housing for two charging receptacles of 100 ampere each. This receptable housing is so designed that the inserted plug can be locked in position, and, when the plug is withdrawn, detachable plates furnished with the housing can be locked over the openings into the receptacles. The lower part serves as a junction box and is equipped with hubs, drilled and tapped for 1¼-inch, 1½-inch or 2-inch conduit.

When the yard charging condulet is mounted on the surface, the two parts, referred to above, are bolted together, by means of heavy hexagon head cap screws, with a gasket placed between the two parts, to insure a water-tight joint. The lower part is supplied with four lugs, or ears, through which bolts pass to secure the condulet to its foundation.

Frequently it is desired to run the conduits underground and have the receptacles elevated to a convenient height. To permit the installation of this yard charging condulet in such a manner, two extension cover plates are provided, one for the receptacle housing and one for the lower part. These extension plates are each furnished with a hub drilled and tapped for 2-inch conduit. They are fastened to their respective parts by means of hexagon head cap screws, gaskets being used to make joints water-tight. The lower part can be placed underground, with the upper part on or above the surface of the ground ,and the two connected by 2-inch

conduit of the desired length. For the convenience of those using the Anderson plug and receptacle, this condulet can be had wtih a cast grid which will accommodate the Anderson type "A" receptacle. The grid and receptacle can readily be mounted within the receptacle housing.

The general design of both receptacle and plug made for type UGC condulet has been carried out with due regard to maintenance and accessibility of the various parts. The receptacle is made of strong composition. The contact parts are perfectly insulated and secured to a moulded composition body by a rocking spring which allows the contact parts to adjust themselves to any angle of the plug. The plug is so made that the contact parts can readily be cleaned. A perfect contact is insured, because there are no openings or crevices to fill with dirt and thereby prevent the proper insertion of the

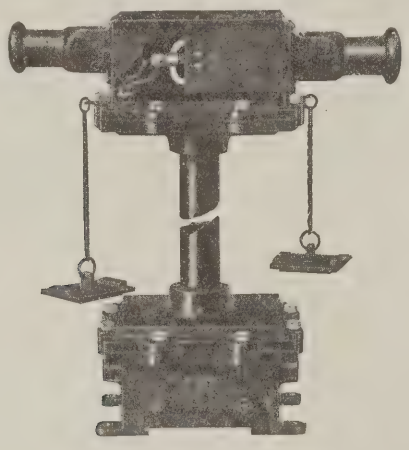


Fig. 4. U. G. C. Condulet arranged for Yard Charging with Underground System.

plug. Should any cinders or dirt collect in the receptacle, the entering plug would force the accumulation into a space provided for it in the rear of the housing.

The plug is of strong construction, being a single piece of best quality, moulded composition, in which contact parts are firmly embedded. A composition, strain relief collar is furnished with each plug, to remove all strain from the wire terminals encased in the handle of the plug. The plug is so designed that a short circuit or a reversal of polarity when the plug enters the receptacle is impossible. It is also provided with barriers, to prevent short circuiting when lying about the yard.

Type FBL and FBR condulets were especially designed to meet the requirements of the Association of Railway Electrical Engineers, calling for a suitable device to accommodate a 100 to 200 ampere fuse for bat-

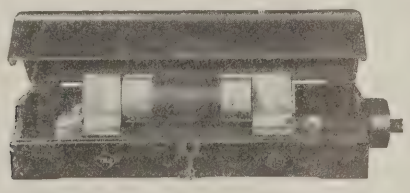


Fig. 5. Type F. B. L. Condulet.

tery circuits on electrically lighted cars. Type FBL is arranged for mounting at the left end and type FBR for mounting at the right end of the battery box. Otherwise the two types are the same.

These condulets are of substantial design and well suited to meet the most severe service. Each is provided with a close fitting hinged cover with catch which protects the contents of the condulet from dust and the weather. Each condulet is regularly furnished with a fuse block to take a 100 to 200 ampere N. E. C. enclosed fuse. Terminal connections are of the soldered type, although the connection leading from the fuse to the battery can be disconnected without unsoldering any connection.

An adjustable fuse holder is made for use with these condulets where it is desired to mount an open link, instead of an enclosed fuse, and will accommodate any open link fuse not less than 2¼ inches or more than 3 inches in length on centers. This fuse holder is pro-

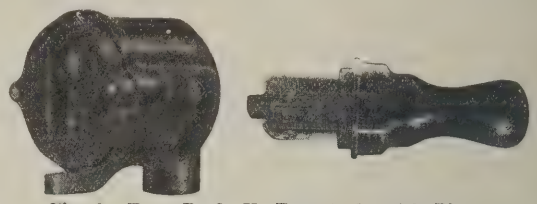


Fig. 6. Type R. Q. K. Receptacle with Plug.

vided with knife blade contact terminals which engage the fuse terminals on the fuse block furnished with the condulet.

Types RQH and RQK receptacles (30 ampere) are so designed that they may be properly mounted in condulets of the QH or QK series, respectively.

Each receptacle consists of a moulded composition body in which copper contacts are placed in such a manner that uniform contact with the current carrying parts of the plug is obtained.

Type RQ plug is for use with either type RQH or RQK receptacle. It is of moulded, insulating composition to which the contacts are firmly secured, and is so constructed as to prevent any strain at the wire terminals.

As the plug can only be inserted in the receptacle in one position, it is impossible to reverse the polarity of the circuit. This will be recognized as a feature of exceptional merit.

Each of the condulets with which type RQH receptacle is used has a hinged cover which can be closed and locked after the plug is removed, thereby preventing the insertion of the plug by an unauthorized person.

Both plug and receptacle, when used with the proper condulet, are exceptionally suited for use in railroad shops, freight houses, round houses, automobile garages, work shops and, in fact, any place where a substantial, well protected receptacle and plug of this capacity are desired.

NEW BOOK ON ALTERNATING CURRENT MACHINERY.

"Alternating Current Machinery" is the title of a new book just published by the American Schools of Correspondence, Chicago. The author, William Esty, takes up the fundamental principles of alternating current, which he so simplifies that they are easily understood by the reader. The author then describes in a simple manner the fundamental principles of measuring instruments, alternators, motors, transformers, converters and switchboard appliances.

This book will be found a good investment for any man operating alternating current machinery. It is well illustrated, with half-tones and diagrams; 467 pages. Price $3.00.

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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Reflector Design.

The article on "Reflecting Media," by Mr. A. J. Sweet, published in this issue, develops some fundamental principles regarding the reflection of light from various surfaces. One of the most general misconceptions in all illuminating engineering is that the reflection of light from all surfaces follows the law, "The angle of reflection equals the angle of incidence," and very many reflectors, particularly of the enameled steel and opal type have been designed with this law as a basis. Subsequently these have been changed after service tests proved them to have been improperly designed.

Whenever a beam of light strikes a surface of opal glass, enameled steel or a painted or papered wall, the light instead of being reflected as a solid beam with reflecting angle being equal to the angle of incidence, is reflected in all directions, and the photometric curve of this diffused beam is approximately a circle tangent at the reflecting surface, with the maximum flux of light perpendicular to the surface of reflector at all times.

Another important point developed by Mr. Sweet is the small influence of a glazed surface on the character of the reflected light. The actual amount of specular reflection from the glazed surface of enamel or glass is very small except at grazing angles, and there is very little change effected in the photometric curve of any porcelain enamel or opal reflector by eliminating the glaze from its surface.

A careful consideration and a better understanding of the laws of reflecting media which are presented in this paper by Mr. Sweet will without doubt result in a more accurate design and better understanding of the use of reflectors both by manufacturers and illuminating engineers in general.

Light As a Shop Efficiency Factor.

Railroad practice of today has been developed largely by mechanical men and the various mechanical operations involved in all the various industries about a railroad shop have been developed to a fairly good point of commercial efficiency.

Shop illumination, one of the biggest and most important factors in the efficiency of any shop, however, is sometimes woefully disregarded, probably due to a lack of appreciation of what good illumination is and its important bearing on shop efficiency.

It actually pays, and pays well, to provide enough illumination to give a wideawake appearance to a shop. This will do a great deal toward increasing the cheerfulness of the men as well as their ability to see better and work faster. It will also largely counteract their tendency to lag as hours of darkness and quitting time approach.

It will be found that the average cost of lighting in a well lighted shop is but 1 per cent. of the total wages paid. This means that if, by having a well lighted shop which both gives the men a cheerful attitude and increases their ability to work, they can save 30 seconds per hour, this will more than pay for the entire cost of the shop lighting. When considered on this basis the answer is self-evident—provide ample and properly designed illumination, placing initial cost and the minimum allowable foot candles in the background.

Good light is a good investment which will bring returns an hundred fold.

The Exhaust Steam Turbine.

The heating problem in a railroad shop is such an important one that where exhaust steam turbines have been installed and operated during the summer time to give a higher economy of either reciprocating engines or high pressure turbines, the general practice has been to discontinue their use in the winter time when it has become necessary to use the exhaust steam in heating the shop. Some installations, however, have recently been designed with a hot water heating system in which the heat of vaporization still remaining in the steam after leaving the exhaust steam turbine is transferred to a hot water heating system.

In the severest months of the winter it may be found necessary to turn additional live steam into the hot water heating system in order to maintain normal temperature in shops, but this will not in any way militate against the successful operation of the exhaust steam heating plant. When this practice of hot water heat becomes more general it will greatly extend the use of exhaust steam turbines in railroad shops at all times of the year.

Roundhouse Wiring.

The report of the Committee on Wiring of Buildings stirred up an interesting discussion on roundhouse wiring at the last A. R. E. E. convention. Obviously one of the most important considerations is to remove all conduit or open wiring, in so far as possible, from the corrosive influence of the steam and gases in the smoke zone of the roundhouse. With the burning of sulphur found in the majority of soft coals, sulpher dioxide is formed. This, together with the steam emitted from the stacks condensing on the cold pipe work above in a little time forms dilute sulphuric acid which rapidly attacks all iron and copper work. This also causes the rubber insulation of the wire to deteriorate very rapidly.

Open wiring on the roof, open wiring or conduit outside the roundhouse just under the eves with condulet taps through the brick wall at each stall, open wiring or conduit placed inside the roundhouse just over the windows and the same installed at various other positions inside the roundhouse, have all been employed with varied success. The system in which the lighting mains are run as open wiring or conduit just under the eves outside the roundhouse, from which taps are made through the wall at each engine stall, however, seems to have the best of the argument.

With the headlight system of roundhouse lighting, it becomes possible to place practically all the wiring and conduit work outside of the roundhouse where it is entirely removed from the corrosive effect of the gases inside the roundhouse,

Association News.

The majority of the committees for the ensuing year have now been appointed and are given in the Association Directory on page 20 of this issue. The personel of four of the committees has not been determined as yet, but this will undoubtedly be published next month.

Secretary Andreucetti states that the specifications which were accepted at the October Convention of the Association are now about ready for letter ballot and will be sent out to the ranking senior active members very soon.

The Question Box.

Mr. C. R. Gilman, Chairman, advises that the "Question Box" is open for business and requests that members send in any questions they may have, addressing him, care C., M. & St. P. Ry., Milwaukee, Wis.

These questions will be published and subsequently answered in the RAILWAY ELECTRICAL ENGINEER, and this department will without doubt prove a valuable addition to the activities of the Association.

St. Louis Car Lighting Club.

The car lighting boys, located at St. Louis, have recently organized a car lighting club and have given it the title of "Pioneer Electric Train Lighting Association." (St. Louis air in the winter time is evidently conducive to a keen sense of humor.)

The officers of the Association are: H. F. Pfeffer, Ch. Elec. Mo. Pac. Ry., President; J. E. Wray, Frisco R. R., Vice President; G. C. Elbreder, Elec. Burlington R. R., Secretary; Thos. C. Birch of the Pullman Co., Treasurer. Board of Governors: C. A. Frank, Big Four; P. B. Streeper, Wabash R. R.; H. P. Reed, and E. A. Corbitt, of the Pullman Company..

The organization though only a little over a month old, has a membership of between seventy and eighty. It is designed to have meetings every two weeks, the first hour of which is given over to a business session, after which the meeting is thrown open and it is the purpose of the organization to have one or more addresses given by prominent people on subjects of interest to Car Lighting Engineers. The addresses are to be along lines of general instruction, as the object of the members is to improve their knowledge of car lighting methods. The meeting held on December 7th had an attendance of sixty odd, the principal address being given by Mr. Fagin of the Crouse Hinds-Company.

RAILWAY ELECTRICAL ENGINEER'S HAND BOOK.

Mr. C. W. Bender, Commercial Engineer of the National Electric Lamp Association, has just completed his new hand book for electrical men. The first edition of this hand book was published about two years ago, but the present edition is thoroughly revised and somewhat enlarged.

It describes all of the various straight storage, head-end and axle generator systems for car lighting, and gives some interesting information on the cost of equipping cars for electric lighting. The author then takes up the general subjects of storage batteries, incandescent lamps, illumination in general and the illumination of passenger equipment, conduit and wire data, general data, tables and definitions.

Under head-end systems the author describes the various types in general use as follows: Straight engine generator system with and without batteries, the Gould booster system, the General Electric system, and the B. & O. system employing lamp regulators on each car.

Under axle generator the author describes the various systems as follows: Newbold. Consolidated types "A, D and L," the Gould Simplex, the Buttner, Brown and Bröveri, Leitner, Mather and Platt, Safety types "F and D," Stone, U. S. Lt. & Htg. Co. types "F, C, P, and S[1]."

Few will appreciate the vast amount of work which has been involved in compiling this hand book. It is only through the untiring efforts of one so well versed in all car lighting matters as Mr. Bender that the publication of this hand book is made possible.

Only a limited edition of these books has been printed. Copies are not for sale, but can be obtained by steam railroad employees who are interested in electric train lighting and illumination, when the request is made through a chief official of a railway department.

ELECTRIFICATION OF THE SWISS RAILWAYS.

The electrification of the State railways of Switzerland is a subject which has been before the Federal Council of that country for several years. After a thorough investigation and considerable experimenting, a commission has reported in favor of the single phase alternating current installation with a trolley voltage of 15,000 volts.

The first application of electrification as motive power for operating the Swiss State railways will be in the St. Gotthard route, where there are many steep grades and numerous tunnels, one of which is over nine miles long. On this line particularly electrification is looked upon with special favor, as it will eliminate the disagreeable passage through many long tunnels filled with smoke.

The commission estimates that the cost of electrification of the entire government system, aggregating 1700 miles, will be approximately $14,000,000.00, including the cost of water power development. The cost of operation, on the other hand, will be reduced about 10 per cent. over present costs with steam power.

New Rock Island Cars

Some of the lighting features of the new cars being placed in service on the Rock Island lines will doubtless be of interest to our readers. The car fixtures are of specially novel design and are shown in the illustration of the interior of the dining car. A satin finish prismatic Holophane reflector with a slightly flaring shirt is used.

Seven Garland ventilators are supplied for providing fresh air in the dining room, and two of these, one placed in the kitchen and one in the doorway in front of the buffet are of the combination blower type described in the *Railway Electrical Engineer* of August, 1912. The blower operates when the train is at slow

Fig. 1. Interior of Diner.

To some this might appear as rather a plain unit for dining car illumination, but the decorative design of the bronze fixture is such as to entirely relieve this. A tosseled skirt extending down over the reflector gives it an effect of artistic draping.

Many fixtures are designed with elaborate bronze decoration above, which shows up very well in daylight. But at night, when the lights are on, the glare of the lighted lamp makes it entirely impossible to see this decorative work. With this fixture, however, the little decoration which is provided, looks very well in the day time, while at night with the lights on it stands silhouetted against the white background of the satin finish reflector.

Five 50 watt lamps are placed in large units down the center of the car, while small units with a shorter fixture stem and 15 watt lamps are placed on the quarter deck, directly over each table.

The car is equipped with Safety type "F" equipment and a Willard train lighting battery of 280 ampere hour capacity. The fixtures were designed by the Safety Car Htg. & Ltg. Co. in conjunction with the Rock Island engineers. These diners are of steel construction throughout, except for the interior finish of the dining room, which is in cherry red mahogany.

speed or in the station, in fact, any time the automatic switch is open it exhausts into a Garland ventilator of special design. This blower exhaust induces an added flow of air through the Garland ventilator even when the car is at rest. A hand switch is provided so that the blower may be turned off at will.

These two blower ventilators being installed in the kitchen and passage way provide a continual exhaust from the kitchen, which prevents any fumes or odors from finding their way into the dining room.

An illumination test of the diner was made, using a Sharp-Millar photometer, and six stations were taken on each of the larger tables with three readings at each station. The results as given on the accompanying diagram show the illumination on the row of test stations, (1) next to the windows, (2) down the center of the tables, (3) near the aisle edge of the tables. The excessively high illumination at one end is due to the influence of the center deck lamp placed over the buffet. At this end this lamp is 4 ft. 7 in. from the adjacent lamp in the dining room, while at the opposite end, the buffet lamp is 7 ft. from the nearest lamp in the dining room. In general, however, it may be said that this car gives a very pleasing effect and as far as the naked eye can observe, the illumination is very uniform.

The satin finished reflectors completely enclose the bare lamps and give a soft, pleasing effect. The walls as well as ceiling are finished in medium dark mahogany, yet the distribution curves of the prismatic reflectors are such that the light is directed to the tables and the reduction of efficiency from the dark walls and ceiling is of little consequence.

The car had been in service for more than six months previous to test, and was tested just as it was received from the road without any cleaning or replacement of lamps or reflectors, so this is strictly a service test.

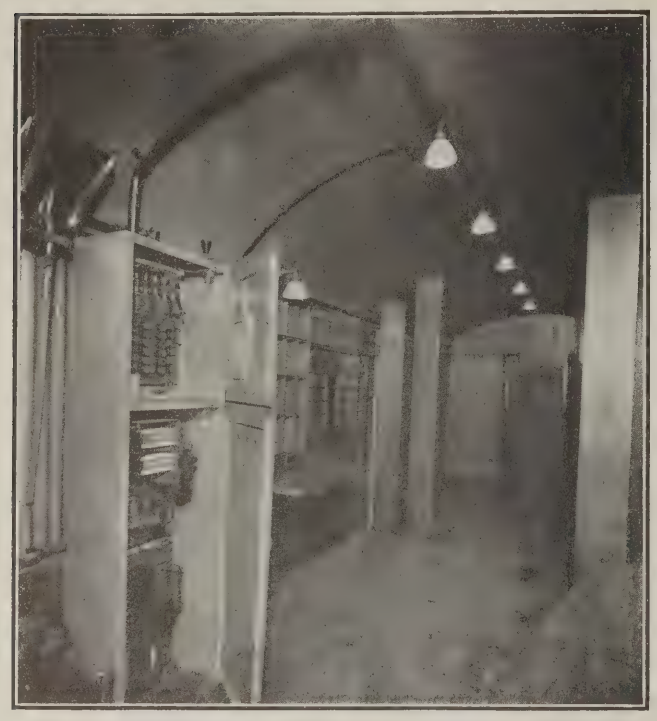

Fig. 2. Switchboard in Baggage Compartment.

TEST DATA.

Average Illumination, 3.04 ft. candles.
Height of Lamp (center deck), 8 ft. 5½ in.
Height of Lamp (quarter deck), 7 ft. 2 in.
Number of lamps in dining room, 5 50 watt; 10 15 watt.
Lamps in front of buffet, 2 50 watt.
Voltage on lamp circuit, 33 volts.
33 volt lamps used in fixtures.
Sharp-Millar photometer used in test.

Station No.	Ft. Candles Illumination.	Station No.	Ft. Candles Illumination.
1	1.90	16	3.70
2	2.66	17	3.06
3	3.01	18	2.30
4	3.29	19	2.19
5	2.70	20	2.90
6	1.99	21	3.54
7	2.57	22	3.59
8	3.26	23	2.99
9	3.93	24	2.26
10	3.91	25	2.57
11	3.24	26	3.47
12	2.57	27	4.30
13	2.31	28	4.76
14	3.03	29	3.70
15	3.76	30	2.86

Baggage Cars.

The baggage compartment of a combination car shown herewith is illuminated by enameled steel reflectors, which are deep enough to entirely hide the lamp when viewed from ordinary positions. 25 watt units are employed. All these are mounted Crouse Hinds condulets at 4 ft. spacings. This small unit at close spacing, as employed in this car, gives a very uniform and well distributed illumination of the room. If, however, it should be desired to use 50 watt lamps instead of 25 watt units, as installed in this car, alternate lamps can easily be removed and the tap in the condulet plugged.

It should be noticed that all conduit work for the wiring of this car is installed inside. The conduit carrying individual wiring circuits is placed in the center of the ceiling, while that carrying the through train lines is placed in the wall just over the door and window line.

The regulator and switchboard panels are mounted in a steel locker as shown in the accompanying illustration. This is divided into two compartments with two separate doors, either of which may be locked. The panels are mounted on "Z" bars, which provide ample room for all wiring behind the board. This is a marked improvement over the older type construction with wiring placed in a wire gutter at the edge of the board. The locker lamps are mounted in a special condulet receptable door switch, and the green pilot lamp on top of the locker connects right through the steel panel to this condulet switch. Safety type "F" lamp regulator and type "D" generator regulator are employed with Willard train lighting batteries of 300 ampere hour capacity.

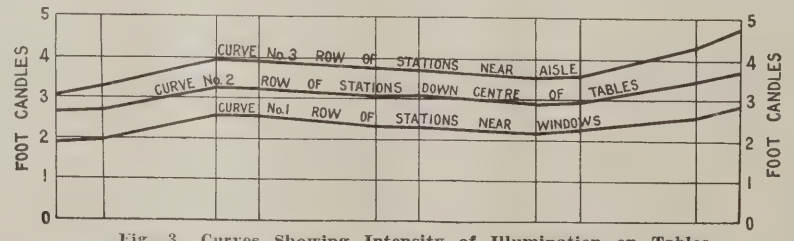

Fig. 3. Curves Showing Intensity of Illumination on Tables.

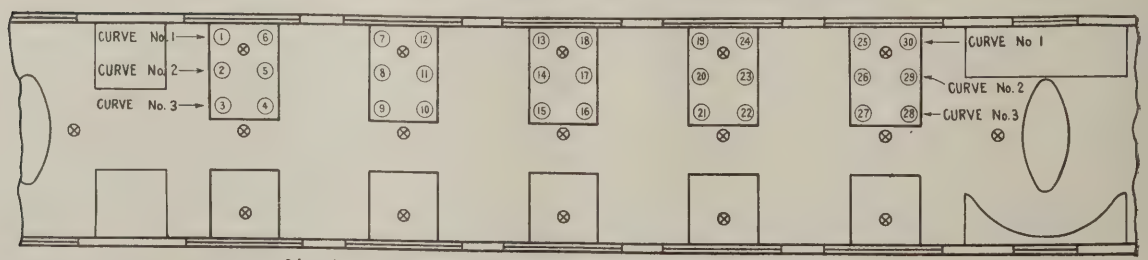

Fig. 4. Diagram of Car Showing Tables and Test Stations.

Reflecting Media

By Arthur J. Sweet, Commercial Engineer with the Holophane Works of the General Electric Company.*

Let us give, the while, free rein to our imagination, and look in upon an office where a number of clerks are working under artificial light. The correspondence or records which the clerks are reading, and the papers upon which they write, lie on flat-top desks about 2½ feet above the floor. The room is lighted by bare lamps located near the ceiling. The lamps throw most of their light on the walls and ceiling where it is absorbed and lost, and only a small amount upon the desks below, where the clerks need it for their work. The illumination on the desks is very dim. The clerks show the effect of the poor illumination by the inefficiency with which they work and by the fact that most of them wear eye-glasses.

The manager enters. He has just learned that, by putting reflectors over his lamps, he can more than double the illumination on the desks of the clerks without increasing in the slightest his lighting bill. The reflectors will intercept the light which is now thrown upon the walls and ceiling and largely lost, and will redirect this light downward upon the desks. The manager orders reflectors installed.

The scene changes. The reflectors have been installed. Unfortunately, however, the reflector is not of a scientifically designed type. It consists of flat strips of silvered glass, fastened together to form a cone-shaped reflector. The reflectors quite efficiently throw the light down upon the desks but give very uneven lighting. Some of the desks are too brightly illuminated, others are not even as bright as they were before reflectors were installed. The manager sees that he is on the right track, but that he will have to find a reflector which not only throws the light down, but re-directs it in each downward direction in such proportion as to give a uniform, even illumination throughout the office.

Again the scene changes. A scientifically designed silvered glass type of reflector has been installed. The desks throughout the room are brightly and uniformly lighted. For a while the manager and the clerks are thoroughly pleased with the new installation. Gradually, however, it begins to be noticed that headaches are of frequent occurrence, and likewise aching or burning of the eyes. Further observation shows that there is a very considerable, though at first unnoticed, reflected glare from the papers or desk surface, directly into the eyes of the clerk at work. This reflected glare is found to be the cause of the headaches and eyeaches, and also to directly interfere with the working efficiency of the clerk. The manager realized that his second choice of reflector has not been suited to the requirements of his service; but he has grown to appreciate the vital importance of good illumination, and he decides to continue his attempts to obtain it.

The next scene shows light-density opal reflectors installed in our office. The illuminating efficiency of this type of reflector was found to be considerably lower than that of the mirrored glass reflector, and at first the illumination on the desks was not bright enough. This defect was remedied, however, by installing a larger size of lamp, with resultant increase in the cost of lighting. Under the new installation, the office has a particularly bright and attractive appearance. The illumination is sufficiently uniform throughout the office, and is of such a character that the reflected glare from the work is not great enough to be seriously objectionable. The clerks are generally pleased with the installation, while the manager feels that the slight increase in lighting cost is well justified if he has at last obtained the long-sought, thoroughly-satisfactory system of lighting.

Our manager, however, is of a scientific turn of mind, and has become, by his experience and by the reading it has suggested, a man well-informed on illumination. He notices that the light-density opal reflectors permit a great deal of light to pass through their sides, and that this light shines into the eyes of the clerk every time he looks up. The light is so well diffused that it causes the clerk no discomfort, but the manager wonders if the working efficiency of the clerk is not affected. He obtains a number of other types of reflectors, and scientific apparatus with which to make the test, and starts in to investigate.

He finds he must separate the typical clerk's work into two conditions,—that when the clerk is looking down and that when he is looking up. So long as the clerk keeps his eyes glued to his work, that illumination is best which is the most diffuse; but when he looks up, that condition of installation is best which sends least light into his eyes. Our manager finds that the light-density opal reflectors permit a comparatively large amount of light to enter the eyes of the clerk every time he looks up; that this light in the eye very appreciably reduces the capacity of the eye to see; and that it requires several moments after the clerk's gaze has dropped again to his work before the normal working efficiency of the eye is regained.

By these simple pen pictures we have indirectly described the line of scientific progress in the history of Illuminating Engineering. At its birth some ten years ago, the science of Illuminating Engineering gave its chief attention to increasing the efficiency of lighting systems by re-directing and utilizing the light which would otherwise have been emitted by the bare lamp source towards walls or ceiling and there largely wasted through absorption. Just as the name of Dr. Louis Bell is inseparably linked with the movement which led to the recognition of Illuminating Engineering as a separate science, so this efficiency period in the science brings first to mind the name of Mr. V. R. Lansingh. The illuminating engineer still finds this efficiency problem one of his chief concerns, but his view-point has, with the passing of the years, become very much broadened.

Illuminating Engineering soon found that it was not sufficient to send the light in some downward direction. The reflector employed must be so designed as to control the light rays and to emit them in proper proportion in each direction, so as to produce the desired result, whether uniform illumination or a concentrating, spot-light effect. Progress along this line was brought to a practical completion in 1909 by the appearance of the author's paper, "Standard Relations of Light Distribution."

The question of light control took on an entirely new aspect as the serious evil of reflected glare from the work began to be generally recognized. In the establishment of this new view-point none has contributed more valuable work than Mr. J. R. Cravath. The science of Illuminating Engineering has just completed this stage of its development, while the practice of Illuminating Engineering is just passing into it.

The science of Illuminating Engineering is now facing the question of light control from the stand-point of the possible evil of excessive light in the eye, whether received directly from the light unit or by reflection from the walls. Authorities are divided as to the objectionable character of such light in the eye, providing the intrinsic brilliancy of the source from which the light is directly received be not too high. The author is one who believes that existing data is sufficient to establish that such light in the eye is objectionable, and frequently very seriously objectionable. If so, a new importance is added to the question of light control.

Through all these changing phases of Illuminating Engineering, through all this broadening aspect of our science, runs the common subject of light control. Illuminating Engineering is at bottom essentially the study of what results ought to be obtained by light control, and of how to obtain such desired light control. A knowledge of the laws upon which light control depends is therefore of fundamental importance and of far-reaching practical value.

No light source has yet been devised, nor, so far as we now know, ever can be, which gives of itself a sufficiently satisfactory type of light distribution. The correct distribution must be obtained by re-directing the light rays after they have been generated by the light source. Re-direction of the light rays can be accomplished to a very limited extent by passing them through a diffusing or refracting medium; but the degree of light control afforded by this means is so slight that control by diffuse transmission or by refraction has properly a very limited application to practice. It is only by reflection of the light rays that an adequate degree of light control can today be obtained.

It is the purpose of this paper to set forth the fundamental laws according to which reflecting media act, and to show the application of these laws to the practical problems of reflector design and choice of reflector.

Probably the most current misconception in the field of Illuminating Engineering is the widespread supposition that all reflecting media operate in accordance with the law, "The angle of reflection equals the angle of incidence." Scarcely a three months period passes that some new reflecting unit is not erroneously designed in accordance with this law, given

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wide commercial prominence, and received and installed in service by able engineers who ought to know better. Of course, such ill-advised types eventually meet their well-deserved fate in that final court of appeal, service. But long before that, another unit, different in appearance but identical in erroneous principle, has appeared and is seeking, not without success, for commercial favor.

The law, the angle of reflection equals the angle of incidence, does apply in all cases to the reflection of the individual, single light ray by the molecular particle. It does not universally apply to the reflection of a beam of parallel rays by a reflecting body of appreciable size. And this latter is the only problem in which, as practical engineers, we are interested.

All reflecting media fall into one of three separate, well-defined classes, each obeying its own unique and independent law of reflection. Any intelligent design, any intelligent choice of reflector for service, must associate the particular reflector in question with the general law under which it operates in reflecting light. These three laws are the Law of Specular Reflection, the Law of Diffuse Reflection and the Law of Spread Reflection.

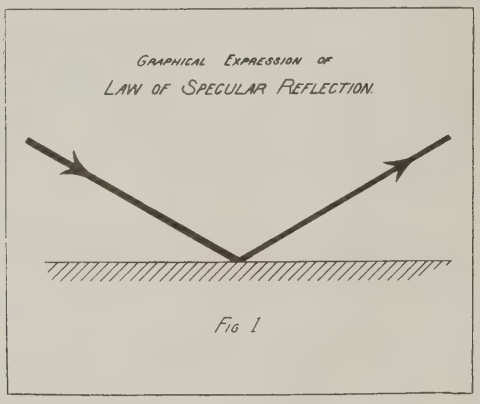


Fig 1

The Law of Specular Reflection is graphically illustrated by Fig. 1. This is the law in obedience to which mirrored reflectors, prismatic clear reflectors, and polished metal reflectors act. Under this law, when a beam of light strikes the reflecting surface, it is reflected, less a certain loss by absorption, in a single direction. This direction depends upon the angle at which the beam strikes the reflecting surface, the law being expressed by the phrase, the angle of reflection equals the angle of incidence.

Theoretically, a specular medium, such as clear prismatic glass or as silvered glass, should give perfect light control; that is, with such a medium, we ought to be able to obtain any desired type of light distribution. To this theoretical condition we could closely approximate in practice if the light source were a point source. Unfortunately, commercial light sources depart very widely from the theoretical point source. When, therefore, any point on the surface of the reflector is designed to reflect in the desired direction the beam which comes from the center of the light source, it may reflect in other than desired directions the beam from the two extreme ends of the light source. As this condition usually works out in practice, the beams from the two extreme ends are reflected in approximately the desired direction but at a greater or less divergence from the exact desired direction.

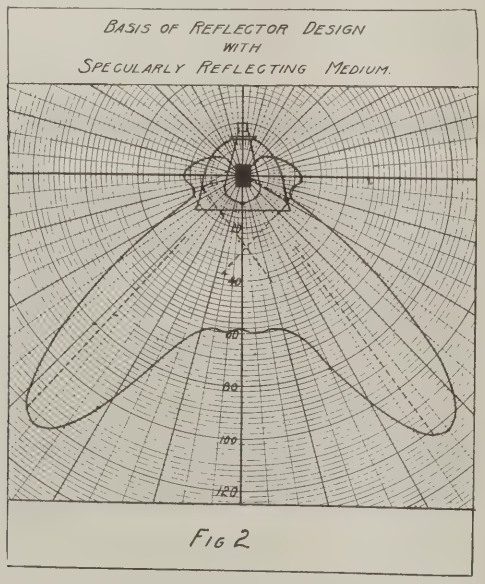


Fig 2

The prismatic reflector permits a certain amount of the light incident upon it to pass through. Such light as is reflected, however, is reflected on the same principle as in the case of the mirrored reflector.

Fig. 2* illustrates the basis on which any reflector obeying the Law of Specular Reflection is designed. The various portions of the surface of the reflector are inclined at such angles to the light source as to reflect the light in proper proportion in the desired direction. The figure shows an actual photometric curve of light distribution, as given by a reflector especially designed to concentrate the light at an angle of 40° from the nadir.

A second class of reflecting media, in which are included porcelain enameled metal reflectors and opal or white glass reflectors of all types whatsoever, obeys the Law of Diffuse Reflection. Most ceiling and wall surfaces also obey this law, which is graphically presented by Fig. 3. Under the Law of Diffuse Reflection, when a beam of light strikes the reflecting body, the parallelism of the rays composing the beam is broken up, and these rays are reflected in every direction through an arc of 180°. The number of rays reflected in each direction are proportionate to the chords of a circle, drawn tangent at the point where the incident beam strikes the reflecting body. The direction of the reflected light is independent of the angle at which the incident beam strikes the reflecting body, the maximum reflection being always perpendicular to the surface of the body.

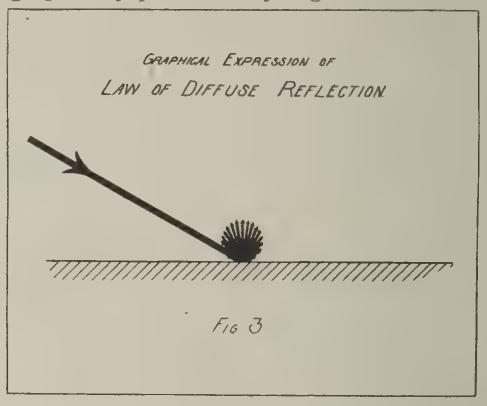


Fig 3

It will at once be seen that diffusely reflecting media afford only very limited possibilities of light control. Reflectors made of such media may efficiently re-direct the light in a general downward direction, but have no capacity to re-direct the light in desired proportion in exact, definite directions. Such a thing, for instance, as a concentrating opal reflector or a concentrating porcelain enameled reflector is an impossibility.

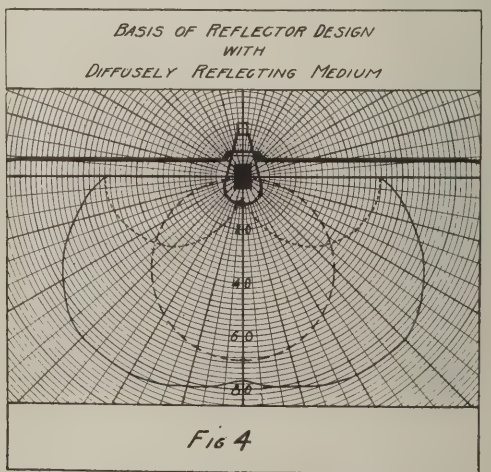


Fig 4

Figs. 4 and 5 will make clear the limitations of diffusely reflecting media in the matter of light control.

Referring to Fig. 4, let us first analyze the results obtained from a flat porcelain reflector, so large that it intercepts

* The photometric curve is a one dimension curve, like a voltage-time curve. Hence to show a reflector and lamp super-imposed on such a curve may possibly lead to a misconception. The method is here followed in the endeavor to make clear the way in which the reflector operates to control the light rays. It should, however, be remembered that, under the scientific conventions upon which the photometric curve is based, the light source, including reflector, is considered to have become a mere point, located at the co-ordinate zero.

practically all of the light emitted by the bare lamp above 90°. The light distribution given by such a unit will be composed of two elements,—the light emitted directly by the bare lamp and not intercepted by the reflector, and the light reflected by the reflector. The intensity of the light emitted by the bare lamp in each downward direction is shown by the short-dot broken line curve. In the matter of reflected light, each minute point on the surface of the reflector will act in accordance with the Law of Diffuse Reflection (Fig. 3), and will reflect the light in each downward direction in proportion to the chord of the tangent circle. Since all these reflecting points lie in a single plane, the sum total of the light reflected by them will be correctly represented by a circle, as shown in the long-dash broken line curve of Fig. 4. By the simple process of adding the direct light and the reflected light, we obtain the light distribution given by the unit as a whole. This is shown in the full line curve of Fig. 4.

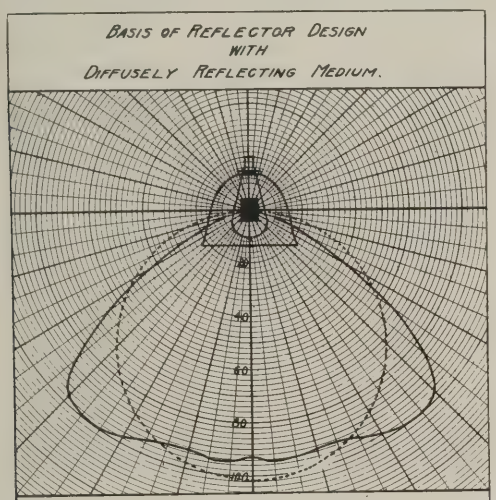


Fig 5

Let us now consider in Fig. 5 a bowl-shaped reflector made from the same media, porcelain enameled metal. Again we have the two elements, the direct light and the reflected light. The reflector intercepts all light above approximately 50°, so the direct element is confined to the 0°-50° zone. As for the reflected light, each minute point on the surface of the reflector obeys by its nature the Law of Diffuse Reflection, and gives a light distribution of the tangent circle type; but the fact that these reflecting points are not on a single plane makes the determination of the nature of their combined light distribution a more complex problem.

Fig. 6 shows diagramatically the reflection from a number of typical points on the reflector surface. At points near the neck of the reflector, the maximum ray (M) is emitted at no very great angular divergence from the vertical, while the vertical ray (V) is of not much lesser magnitude than the maximum. Light reflected from points near the top of the reflector therefore tends to build up the end-on or vertical candle-power of the complete unit. The rays not included between the two black-faced rays are reflected at such angles as to be a second time intercepted by the reflector surface, and they therefore undergo a second reflection, with consequently increased absorption losses.

As reflecting points further and further from the neck are considered, it is seen that the angular divergence of the maximum ray from the vertical increases, while the magnitude of the vertical ray diminshes. Before the point midway between the neck and the mouth of the reflector is reached the maximum ray is reflected at such divergence from the vertical as to be again intercepted by the reflector surface and undergo second reflection. The tendency, therefore, of light reflected by the middle and lower portions of the reflector is to increase the candle-power of the unit as a whole at the higher angles. This tendency, however, is counteracted by the intercepting or eclipsing action of the reflector itself; so that at some angle, such as 40° in Fig. 5, the two tendencies just balance, and the candle-power, which has been increasing from 0° to this angle, begins to diminish.

Figure 5 presents a truly typical curve of the light distribution given by a diffusely reflecting medium. The dotted curve, which represents the same total amount of light as the full line curve, is the theoretical curve of diffuse reflection, unmodified by any direct light or by any eclipsing action of the reflector. A comparison of the two curves brings out clearly the tendency of the candle-power, in the case of the actual bowl-shaped reflector, to increase with increased angular divergence from zero degrees until this increase is checked and the candle-power gradually reduced to nothing by the eclipsing action of the reflector.

The above discussion applies equally to an opal reflector, as well as to a porcelain enameled reflector. The only difference in the case of the opal reflector is the non-essential one that the reflector gives in addition a certain amount of transmitted light.

The above discussion broadly indicates the very limited degree to which any exact condition of light control can be obtained with a diffusely reflecting medium. If all that is desired in a general downward reflection of the light, with a shape of distribution varying between that of the full line curve of Fig. 5 and the short dash, broken line curve of Fig. 7, such results can very satisfactorily be obtained by an opal or porcelain enameled reflector; but if concentration of the light at zero degrees or at any other angle (see Fig. 2) is desired, such results can only be obtained by a mirrored or prismatic type of reflector.

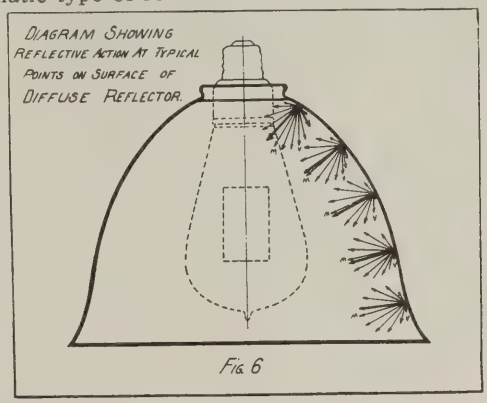


Fig 6

Fig. 6 also makes clear that multiple internal reflection is the chief cause of light absorption in a reflector acting by diffuse reflection. Opal glasses can be obtained having almost or quite as high a coefficient of reflection as silvered glass. Porcelain enamels can be obtained with a high though not as good co-efficient of reflection. But whereas, in the case of the mirrored or prismatic reflector, the ray is reflected once and then directed out through the mouth of the reflector, in the case of the opal or porcelain enameled reflector, the ray may be reflected back and forth within the reflector many times before it finally escapes through the mouth of the reflector. This factor of inefficiency is intrinsic with all diffusely reflecting media and cannot be eliminated. Its objectionable influence can be considerably lessened, however, by employing an opal or porcelain having a high co-efficient of reflection, so that the amount absorbed at each added reflection is as low as possible.

Opal glasses differ very widely in the relative proportions in which they reflect and transmit the light incident upon them. The greater the optical density of the opal, the greater will be the amount of light reflected by it and the less the transmitted light. On the other hand, the greater the optical density, the greater the loss of light by absorption. This arises from the fact that most of the rays cannot get through the reflector wall of dense opal glass, and are therefore reflected and re-reflected until they at last escape through the mouth of the reflector. However, since the office of a reflector is not merely to screen the light source but to re-direct the light rays, an opal glass of at least moderate density must be employed if the reflector is to fulfill this latter function at all satisfactorily.

Opal reflectors are generally classified as light density opal reflectors, medium density opal reflectors and heavy density opal reflectors. While no sharp line of division can be drawn between the three classes, the classification is proper and convenient. The light density opal reflector, which at present, being pushed on the market for purely commercial reasons, has considerable vogue, gives so relatively small an amount of reflection as to make it decidedly inferior to the heavier density opal types in most classes of service.

Considerable difference in shape of opal or other diffuse reflectors makes only slight difference in the type of light distribution given thereby. This naturally follows in the nature of a corrollary from the application of the Law of Diffuse Reflection. Since the distribution of reflected light from any point on the reflecting surface is represented by a tangent circle, a very considerable change in the slope of the surface must be made before the magnitude of light reflected in any given direction is greatly changed. Moreover, considerations of appearance and of adequate screening of the light source quite definitely pre-determine reflector size,

—that is, diameter and height. Hence, as between two diffuse reflectors designed for the same size of lamp, if one slopes more steeply near the neck, it will of practical necessity slope less steeply near the mouth. The differences in distribution of reflected light from points near the neck and from points near the mouth are therefore in opposite direction, and largely compensate each for the other.

Change in position of light source relative to reflector does not affect to any considerable degree the nature of the light distribution given by a diffuse reflector. It has already been pointed out that the amount of light reflected in each direction depends, at any point, on the slope of the reflecting surface and not in the least upon the angle at which the incident light strikes that surface. If this were the only consideration, therefore, change in lamp position would have absolutely no effect on light distribution. There are, however, two other considerations. (1) As the position of light source is raised in the reflector, the direct light is eclipsed to a greater and greater degree. This slightly modifies the distribution of the light unit, in the direction of reducing the candle-power at the higher angles. (2) As the

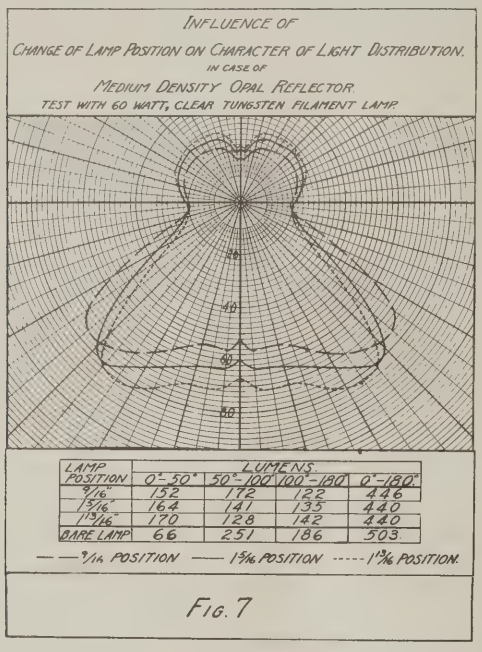

INFLUENCE OF
CHANGE OF LAMP POSITION ON CHARACTER OF LIGHT DISTRIBUTION.
IN CASE OF
MEDIUM DENSITY OPAL REFLECTOR.
TEST WITH 60 WATT, CLEAR TUNGSTEN FILAMENT LAMP.
20
40
60
80
LAMP POSITION | LUMENS 0°-50° | 50°-100° | 100°-180° | 0°-180°
3/16" | 152 | 172 | 122 | 446
1 3/16" | 164 | 141 | 135 | 440
1 13/16" | 170 | 128 | 142 | 440
BARE LAMP | 66 | 251 | 186 | 503
— — 3/16 POSITION —— 1 3/16 POSITION ----- 1 13/16 POSITION.

FIG. 7

position of the light source is raised in the reflector, an increased amount of incident light falls upon reflecting points near the neck. This tends, with the reflector shapes usually employed, to slightly increase the end-on candle-power and to slightly diminish the candle-power at the higher angles. The net effect, therefore, of changes in position of light source is to give slightly greater end-on candle-power and less light at the higher angles as the light source is raised. Fig. 7, shows on a representative basis the degree to which the type of light distribution is changed by change in lamp position. It will be noted that the changes in shape of curve are relatively small, although the changes in lamp position are comparatively large.

Fig. 8 shows on a correctly representative basis the extent to which similar changes in lamp position effect changes in light distribution in the case of a prismatic reflector. The opal reflector of Fig. 7, and the prismatic reflector of Fig. 8 have identically the same shape, and the corresponding lamp positions at which the tests were made are identical. The very high degree of light control afforded by a prismatic reflector and the very slight degree afforded by an opal reflector is strikingly brought out by a comparison of these two figures. It will of course be understood that a mirrored reflector would give in this respect similar results to a prismatic, while a porcelain enameled metal reflector would give similar results to an opal reflector.

A very general misconception exists, even among Illuminating Engineers, as to the degree to which a heavy glaze may modify the type of light distribution given by an opal or porcelain enameled reflector. Such reflection of light as is accomplished by the glaze itself, rather than by the reflector body behind the glaze, obeys the Law of Specular Reflection. Hence, such glaze-reflected light is susceptible to a very high degree of light control. Most previous discussions of this subject leave the impression that the amount of such glaze-reflected light may, in the case of a heavily glazed reflector, be sufficient to materially modify the type of light distribution. This impression is thoroughly erroneous. In

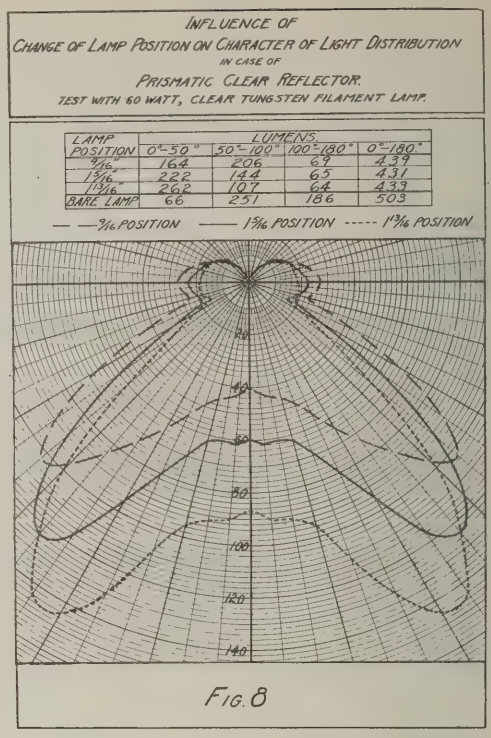

INFLUENCE OF
CHANGE OF LAMP POSITION ON CHARACTER OF LIGHT DISTRIBUTION
IN CASE OF
PRISMATIC CLEAR REFLECTOR.
TEST WITH 60 WATT, CLEAR TUNGSTEN FILAMENT LAMP.
LAMP POSITION | LUMENS 0°-50° | 50°-100° | 100°-180° | 0°-180°
3/16" | 164 | 206 | 69 | 439
1 3/16" | 222 | 144 | 65 | 431
1 13/16" | 262 | 107 | 64 | 433
BARE LAMP | 66 | 251 | 186 | 503
— — 3/16 POSITION —— 1 3/16 POSITION ----- 1 13/16 POSITION
20
40
60
80
100
120
140

FIG. 8

order for the glaze to reflect of itself any considerable amount of light, it is necessary for the incident light to strike the glazed surface at a comparatively grazing angle. In a bowl-shaped reflector of practical shape and dimensions, it is impossible to have any considerable amount of light strike the reflecting surface at such grazing angle. The glaze in any practical and satisfactory type of opal or porcelain enameled reflector, has, therefore, a negligable effect in modifying the light distribution.

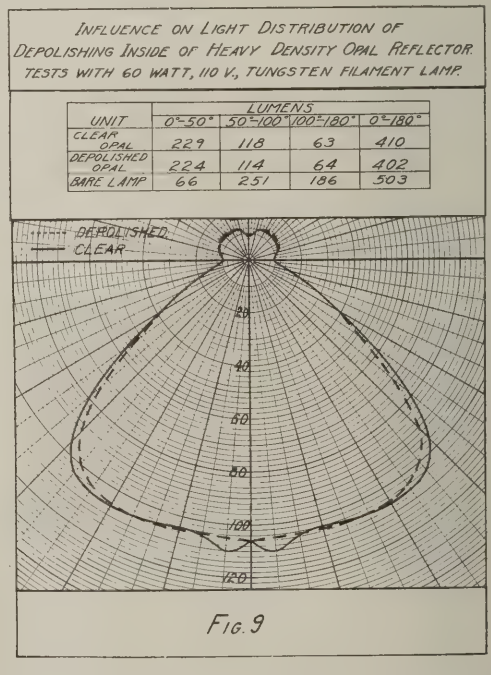
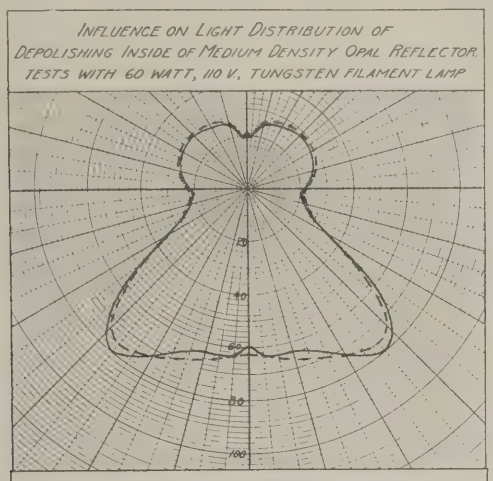

INFLUENCE ON LIGHT DISTRIBUTION OF
DEPOLISHING INSIDE OF HEAVY DENSITY OPAL REFLECTOR.
TESTS WITH 60 WATT, 110 V, TUNGSTEN FILAMENT LAMP.
UNIT | LUMENS 0°-50° | 50°-100° | 100°-180° | 0°-180°
CLEAR OPAL | 229 | 118 | 63 | 410
DEPOLISHED OPAL | 224 | 114 | 64 | 402
BARE LAMP | 66 | 251 | 186 | 503
DEPOLISHED
CLEAR
20
40
60
80
100
120

FIG. 9

It would be possible to design a reflector whose light distribution would be modified to small yet appreciable degree by light specularly reflected from the glaze. But such design would almost invariably involve objectionable features of a nature to unfit the reflector for practical service.

Figs. 9 and 10 are typical of the small degree to which glaze-reflected light modifies the light distribution in the case of practical commercial shapes of reflector. The reflector of Fig. 9 was a heavy density opal, that of Fig. 10 a medium density opal. Both reflectors had an extreme degree of glaze. The reflectors were tested in their initial glazed condition and again after the glaze had been thoroughly etched off. It will be noted that the glaze had an entirely negligable effect in modifying the light distribution.

No error of sufficient magnitude to be of any practical importance will be made by assuming that all opal and porcelain enameled media obey perfectly the Law of Diffuse Reflection.


INFLUENCE ON LIGHT DISTRIBUTION OF
DEPOLISHING INSIDE OF MEDIUM DENSITY OPAL REFLECTOR.
TESTS WITH 60 WATT, 110 V, TUNGSTEN FILAMENT LAMP

UNIT	LUMENS 0°-50°	50°-100°	100°-180°	0°-180°
CLEAR OPAL	162	144	139	445
DEPOLISHED OPAL	161	144	144	449
BARE LAMP	66	251	186	503

FIG. 10

From the foregoing extended discussion of the operation of the Law of Diffuse Reflection in practice, it should be emphatically evident that all attempts to design or to employ opal or porcelain enameled media as though they obeyed the Law of Specular Reflection are foredoomed to failure.* All talk of "concentrating" porcelain enameled reflectors, of the "focus" of such reflectors, of "Extensive" or "Focusing" opal reflectors, betokens on the part of him who is guilty of it the most extreme ignorance of the laws according to which reflecting media operate.

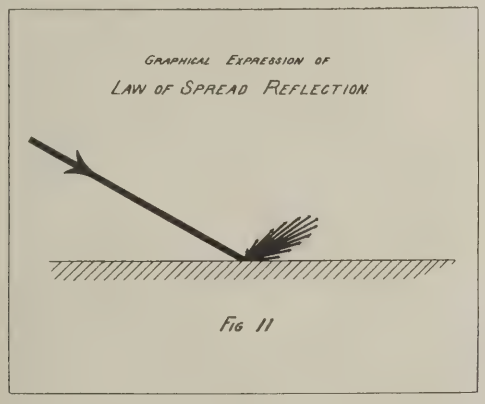
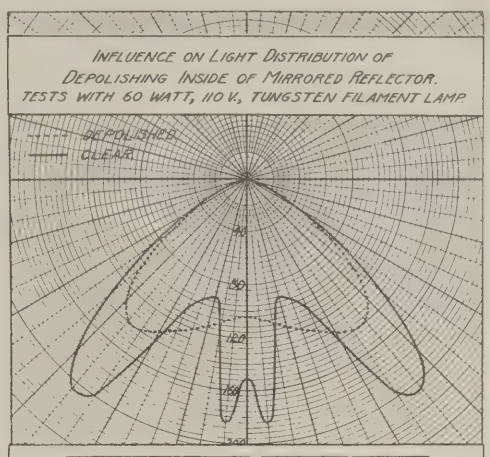


FIG 11

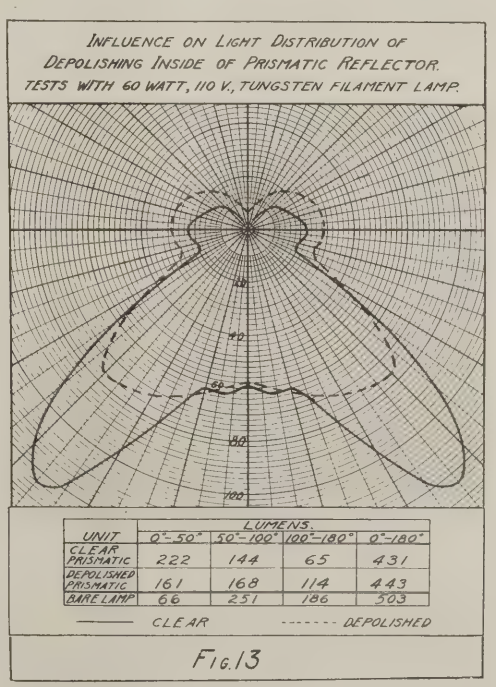
There is a third class of reflecting media which essentially consists of depolished specular media. The most prominent commercial types representative of this class are the satin-finished prismatic reflector and the aluminumized metal reflector. A satin-finished or depolished mirrored reflector would also belong to this class. This class acts in obedience to the Law of Spread Reflection, which is graphically expressed by Fig. 11. In spread reflection, the reflected light tends to obey the Law of Specular Reflection, but there is a greater or less spreading of the rays. The maximum reflection of light always occurs at an angle equal to the angle of incidence.


INFLUENCE ON LIGHT DISTRIBUTION OF
DEPOLISHING INSIDE OF MIRRORED REFLECTOR.
TESTS WITH 60 WATT, 110 V, TUNGSTEN FILAMENT LAMP.
DEPOLISHED
CLEAR

UNIT	LUMENS 0°-50°	50°-100°	100°-180°	0°-180°
CLEAR MIRRORED	358	87	00	445
DEPOLISHED MIRRORED	288	96	00	384
BARE LAMP	66	251	186	503

FIG 12

Media obeying the Law of Spread Reflection afford a considerably greater degree of light control than diffuse media, and a considerably lesser degree than specular media. The extent to which light control is lost by satin-finishing a mirrored or prismatic reflector is clearly brought out by Figs. 12 and 13. These figures are correctly representative of the relative degree of light control afforded by spread and by specular media; but they do not correctly indicate the relative degree afforded by spread and diffuse media. By designing the clear mirrored or prismatic reflector to give a more


INFLUENCE ON LIGHT DISTRIBUTION OF
DEPOLISHING INSIDE OF PRISMATIC REFLECTOR.
TESTS WITH 60 WATT, 110 V, TUNGSTEN FILAMENT LAMP.

UNIT	LUMENS 0°-50°	50°-100°	100°-180°	0°-180°
CLEAR PRISMATIC	222	144	65	431
DEPOLISHED PRISMATIC	161	168	114	443
BARE LAMP	66	251	186	503

——— CLEAR ------- DEPOLISHED

FIG. 13

* Because of the general misconception on this subject, the foregoing discussion emphasizes the very limited degree to which light control can be obtained with a diffusely reflecting medium. It would be very erroneous to conclude from the preceding discussion that opal reflectors have little or no correct application to scientific illumination practice. As has been pointed out, there is practically only one shape of curve which can be obtained with a diffuse reflector, this being of the type which is generally designated as "Intensive." It fortunately happens that the Intensive type of curve is the one which has most general application to practice.

A correct interpretation of the facts set forth in this article will lead to the realization of the two following important considerations effecting the application of opal or porcelain reflectors to scientific illumination practice.

(1) The opal or porcelain reflector may be satisfactorily applied to many though by no means all cases where the requirements call for a broader or less broad curve of the "Intensive" type; but the opal or porcelain reflector can never be satisfactorily applied to service where the requirements call for a Concentrating, "Focusing" or "Extensive" type of curve.

(2) The design and the application to practice of opal glass reflectors and porcelain enameled metal reflectors should be based on a larger knowledge of the scientific principles involved than is now generally the case.

extreme degree of concentration at the desired angle, say at 40° as in the figures, the satin-finished form would give a correspondingly increased candle-power at such angle. It is possible by these means to obtain a much greater degree of light control than would be possible with a diffuse medium, though never anywhere near as great a degree as would be possible with a specular medium.

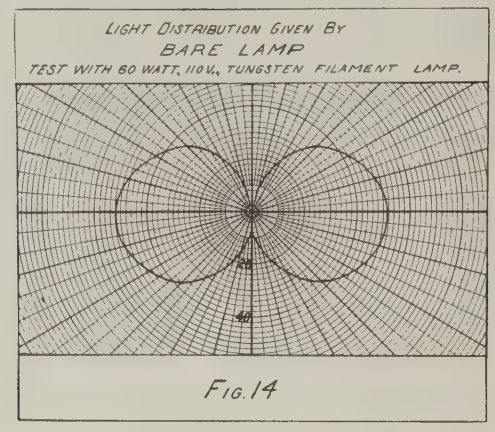


FIG. 14

In point of the influence upon type of light distribution produced by change of reflector shape or of lamp location, reflectors following the Law of Spread Reflection occupy a position intermediate between specular and diffuse reflectors.

The foregoing portions of this paper set forth the principles in accordance with which reflecting media act. It will now be of interest and value to observe the actual operation of these principles under conditions correctly and broadly representative of actual practice.

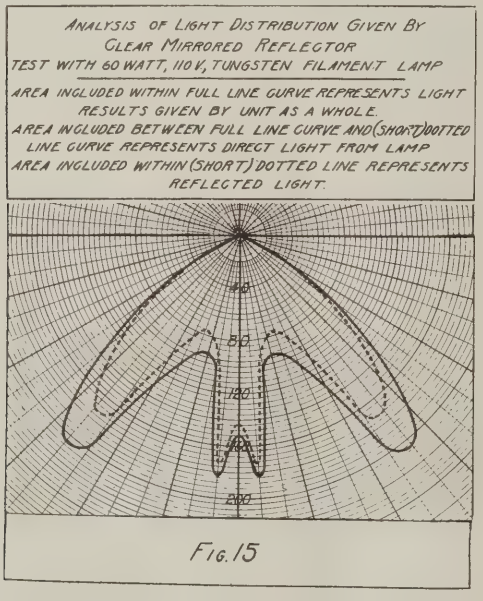

ANALYSIS OF LIGHT DISTRIBUTION GIVEN BY
CLEAR MIRRORED REFLECTOR
TEST WITH 60 WATT, 110 V, TUNGSTEN FILAMENT LAMP
AREA INCLUDED WITHIN FULL LINE CURVE REPRESENTS LIGHT RESULTS GIVEN BY UNIT AS A WHOLE.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (SHORT) DOTTED LINE CURVE REPRESENTS DIRECT LIGHT FROM LAMP.
AREA INCLUDED WITHIN (SHORT) DOTTED LINE REPRESENTS REFLECTED LIGHT.

FIG. 15

Various types of reflecting media, representative of all classes at all extensively employed in actual practice, were made up into reflectors of exactly similar shape and size. The reflector shape employed was that shown in Fig. 6. These reflectors were tested with the standard 60 watt, 110 volt, clear bulb tungsten filament lamp, the lamp position in the reflector being the same for all tests. In the case of translucent types, the reflector was first tested in the usual fashion, and then tested again with the outside surface surrounded by a black velvet cover. By camparison of these two tests, the amount of light transmitted through the reflector could be determined. The total amount of light emitted by the bare lamp being known, the absorption produced by the reflector was easily determined. By computation in connection with test data on the bare lamp, the amount of direct light, not intercepted by the reflector, was determined. In this way, the direct light, the reflected light, the transmitted light, and the absorbed light were separated and evaluated for each type of reflector. The data thus obtained affords a most complete and adequate means of corroborating by actual test the truth of the principles previously here set forth.

Fig. 14 shows the light distribution results given by the bare tungsten filament lamp. The generally recognized necessity for the use of reflectors is well brought out by this curve. The lamp throws the maximum amount of light towards the walls, where such light will be largely absorbed; a very considerable amount of light is thrown towards the

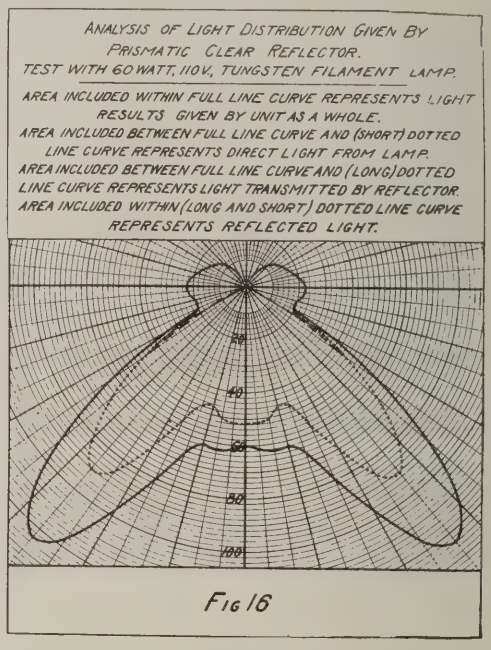

ANALYSIS OF LIGHT DISTRIBUTION GIVEN BY
PRISMATIC CLEAR REFLECTOR.
TEST WITH 60 WATT, 110 V, TUNGSTEN FILAMENT LAMP.
AREA INCLUDED WITHIN FULL LINE CURVE REPRESENTS LIGHT RESULTS GIVEN BY UNIT AS A WHOLE.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (SHORT) DOTTED LINE CURVE REPRESENTS DIRECT LIGHT FROM LAMP.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (LONG) DOTTED LINE CURVE REPRESENTS LIGHT TRANSMITTED BY REFLECTOR.
AREA INCLUDED WITHIN (LONG AND SHORT) DOTTED LINE CURVE REPRESENTS REFLECTED LIGHT.

FIG 16

ceiling; and only about 15% of the total light is thrown in useful directions. Of course, some of the light emitted by the bare lamp towards the walls or ceiling will be reflected by them in such directions as to be useful; but under average installation conditions at least 80% of the light emitted towards the walls and ceiling will eventually be absorbed without being useful.

A striking change over the results given by the bare lamp is shown when the mirrored reflector is employed (Fig. 15). The high degree of light control and the efficiency at which

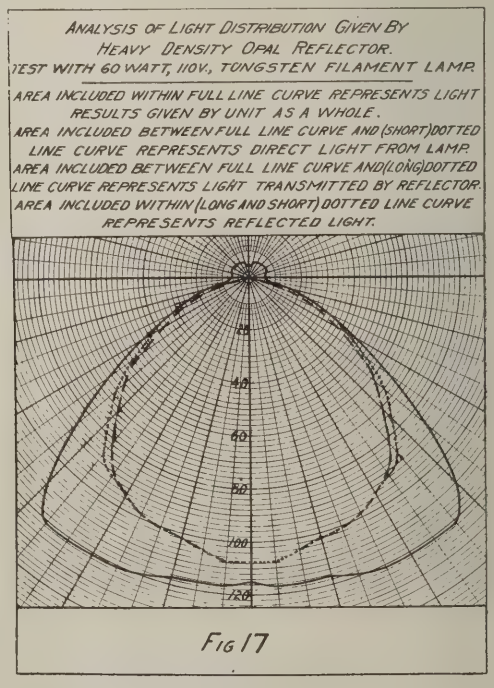

ANALYSIS OF LIGHT DISTRIBUTION GIVEN BY
HEAVY DENSITY OPAL REFLECTOR.
TEST WITH 60 WATT, 110 V., TUNGSTEN FILAMENT LAMP.
AREA INCLUDED WITHIN FULL LINE CURVE REPRESENTS LIGHT RESULTS GIVEN BY UNIT AS A WHOLE.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (SHORT) DOTTED LINE CURVE REPRESENTS DIRECT LIGHT FROM LAMP.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (LONG) DOTTED LINE CURVE REPRESENTS LIGHT TRANSMITTED BY REFLECTOR.
AREA INCLUDED WITHIN (LONG AND SHORT) DOTTED LINE CURVE REPRESENTS REFLECTED LIGHT.

FIG 17

this control is produced is apparent at a glance. It should be noted that the mirrored reflector results are plotted to a smaller scale than that employed in the other curves here presented.

ANALYSIS OF LIGHT DISTRIBUTION GIVEN BY HEAVY DENSITY OPAL REFLECTOR
TEST WITH 60 WATT, 110 V, TUNGSTEN FILAMENT LAMP

AREA INCLUDED WITHIN FULL LINE CURVE REPRESENTS LIGHT RESULTS GIVEN BY UNIT AS A WHOLE
AREA INCLUDED BETWEEN FULL LINE CURVE AND (SHORT) DOTTED LINE CURVE REPRESENTS DIRECT LIGHT FROM LAMP.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (LONG) DOTTED LINE CURVE REPRESENTS LIGHT TRANSMITTED BY REFLECTOR.
AREA INCLUDED WITHIN (LONG AND SHORT) DOTTED LINE CURVE REPRESENTS REFLECTED LIGHT.

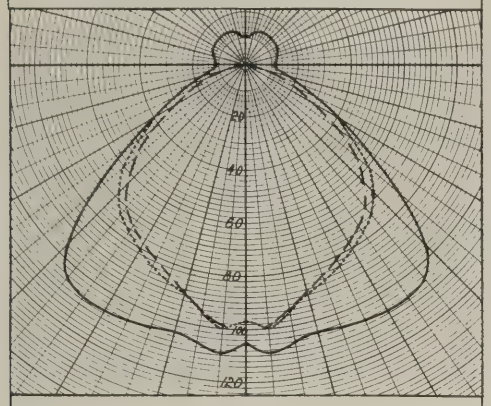


FIG 18

ANALYSIS OF LIGHT DISTRIBUTION GIVEN BY MEDIUM DENSITY OPAL REFLECTOR.
TEST WITH 60 WATT, 110V, TUNGSTEN FILAMENT LAMP

AREA INCLUDED WITHIN FULL LINE CURVE REPRESENTS LIGHT RESULTS GIVEN BY UNIT AS A WHOLE.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (SHORT) DOTTED LINE CURVE REPRESENTS DIRECT LIGHT FROM LAMP.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (LONG) DOTTED LINE CURVE REPRESENTS LIGHT TRANSMITTED BY REFLECTOR.
AREA INCLUDED WITHIN (LONG AND SHORT) DOTTED LINE CURVE REPRESENTS REFLECTED LIGHT.

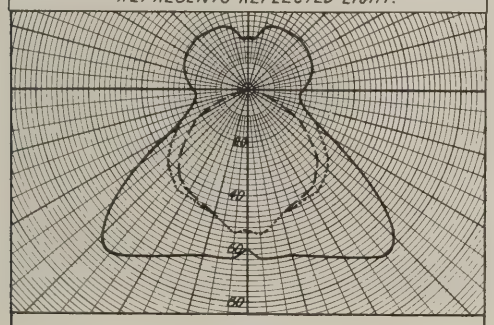
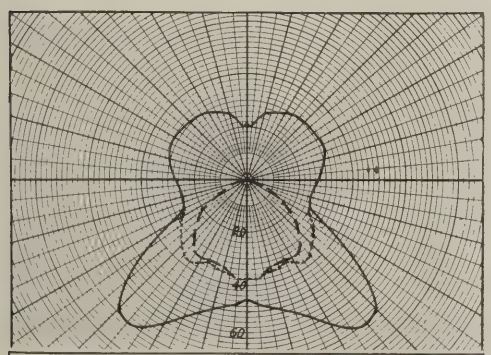


FIG. 19



ANALYSIS OF LIGHT DISTRIBUTION GIVEN BY LIGHT DENSITY OPAL REFLECTOR.
TEST WITH 60 WATT, 110V, TUNGSTEN FILAMENT LAMP.

AREA INCLUDED WITHIN FULL LINE CURVE REPRESENTS LIGHT RESULTS GIVEN BY UNIT AS A WHOLE.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (SHORT) DOTTED LINE CURVE REPRESENTS DIRECT LIGHT FROM LAMP.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (LONG) DOTTED LINE CURVE REPRESENTS LIGHT TRANSMITTED BY REFLECTOR
AREA INCLUDED WITHIN (LONG AND SHORT) DOTTED LINE CURVE REPRESENTS REFLECTED LIGHT.

FIG 20

In Fig. 15, as in similar subsequent figures, the direct, the reflected, the transmitted, and the total light are separately shown. The full line curve shows the total light emitted by the unit. The co-ordinates between the short-dot broken line and the full line represent the direct light. In the case of the mirrored reflector, there is, of course, no transmitted light. Finally, the co-ordinates measured off by the dotted line show the reflected light.

One of the most essential things to observe in this and subsequent figures is the shape of the curve of reflected light (always the innermost curve). The shape of this curve is especially indicative of the degree of light control afforded by the particular reflecting medium under consideration. In the example here before us, the remarkable concentration of the light at 40° shows the high degree of light control afforded by the mirrored reflector.

Fig. 16 shows the light distribution given by the clear prismatic reflector. Again the curve serves to illustrate and emphasize the high degree of light control given by a specular medium. This is also very strikingly brought out by Fig. 8. A medium which can, by mere change in lamp position, produce three such notably different curves as those of Fig. 8. must of necessity afford a very high degree of light control.

A comparison of the full line curves of Figs. 15 and 16 bring out the fact that, although both media act in accordance with the Law of Specular Reflection, there are minor design differences as between the mirrored and prismatic types. The action on the above law is modified, to small degree in the case of the prismatic reflector by the transmission of light which takes place through the sides of the reflector. The light which, in the case of the mirrored reflector, causes the marked projection of the curve near 0° is almost entirely transmitted in the prismatic reflector.

Figs. 17 to 20 inclusive show the light distributions given by four representative opal types. In comparing these curves, the first thing to be observed is that their curves of reflected light are all very similar in shape, though all radically different from the reflected light curves of the prismatic and mirrored types. The reflected light curve of any one of the four opal reflectors splendidly illustrates the operation of the Law of Diffuse Reflection, and the slight degree of light control given thereby. In this connection it will be remembered that the curve of diffuse reflection is always a modified circle, as described above in the discussion of Figs. 4, 5 and 6.

The second feature brought out by Figs. 17 to 20 is the great variation in the proportionate amounts of reflected and transmitted light. The heavy density opal type reflects by far the larger amount of light, and has, therefore, the greater illuminating efficiency. Its only objectionable feature is that, transmitting so little light towards the ceiling, it is apt to give an illumination not so diffuse as could be desired; and that is especially the case if the inside surface of the reflector is not depolished. The heavy density types here shown emit little light toward the walls or toward the eye, a highly commendable feature from the standpoints both of illuminating efficiency and of minimum eye-strain and maximum eye efficiency.

The heavy density opal reflector of Fig. 17 is, in its reflecting efficiency, much superior to rather than representative of the average heavy density opal reflector to-day on the market This particular opal, which has as yet been placed on the market in only a few reflector shapes, represents the highest quality level which has yet been attained by a heavy density opal type. Its light absorption is remarkably low for a glass of such heavy density and marked reflecting powers. Incidentally, it is a glass of notably beautiful appearance. Where ceilings are dark and the service requirements permit the use an opal reflector with fully satisfactory results, this so-called White Iris reflector is superior to all others, and doubly so if artistic considerations are of importance.

The light density opal reflector of Fig. 20 is the type of opal reflector which has at present greatest commercial vogue. This vogue is due to no excellence of the reflector type, but chiefly to the strong commercial backing which it is receiving, and, in lesser measure, to the fact that it appeals to certain popular misconceptions of what is desirable in a reflector. It reflects less than one-third as much light as the White Iris reflector of Fig. 17. Most objectionable of all, it emits a large amount of light toward the walls, where such light will be most inefficiently utilized and toward the eye where such light will tend to produce eye-strain and eye-inefficiency.

It is proper here to say that the manufacturers of the particular light density opal glass employed in the test reflector have apparently made changes within the past year in the constitution of their glass, these changes being in the direction of increased optical density. These changes are not,

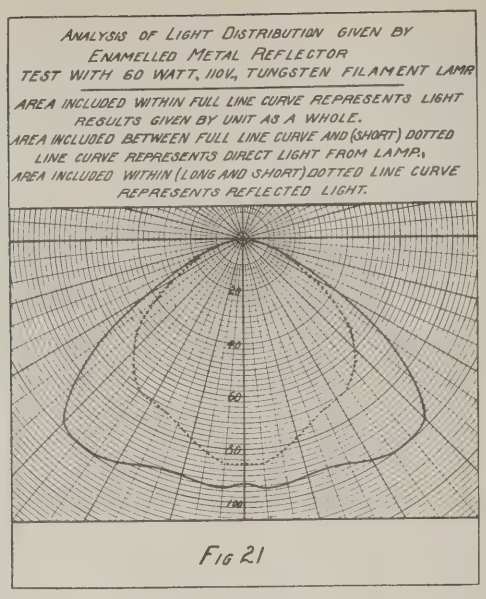
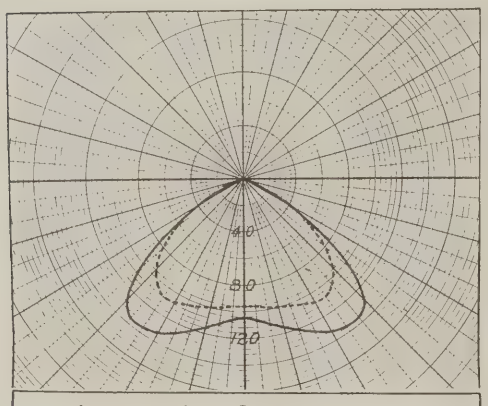

ANALYSIS OF LIGHT DISTRIBUTION GIVEN BY
ENAMELLED METAL REFLECTOR
TEST WITH 60 WATT, 110V, TUNGSTEN FILAMENT LAMP
AREA INCLUDED WITHIN FULL LINE CURVE REPRESENTS LIGHT RESULTS GIVEN BY UNIT AS A WHOLE.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (SHORT) DOTTED LINE CURVE REPRESENTS DIRECT LIGHT FROM LAMP.
AREA INCLUDED WITHIN (LONG AND SHORT) DOTTED LINE CURVE REPRESENTS REFLECTED LIGHT.
20
40
60
80
100

FIG 21



ANALYSIS OF LIGHT DISTRIBUTION GIVEN BY
DEPOLISHED MIRRORED REFLECTOR.
TEST WITH 60 WATT, 110 V, TUNGSTEN FILAMENT LAMP.
AREA INCLUDED WITHIN FULL LINE CURVE REPRESENTS LIGHT RESULTS GIVEN BY UNIT AS A WHOLE.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (SHORT) DOTTED LINE CURVE REPRESENTS DIRECT LIGHT FROM LAMP.
AREA INCLUDED WITHIN SHORT DOTTED LINE CURVE REPRESENTS REFLECTED LIGHT.

FIG 22

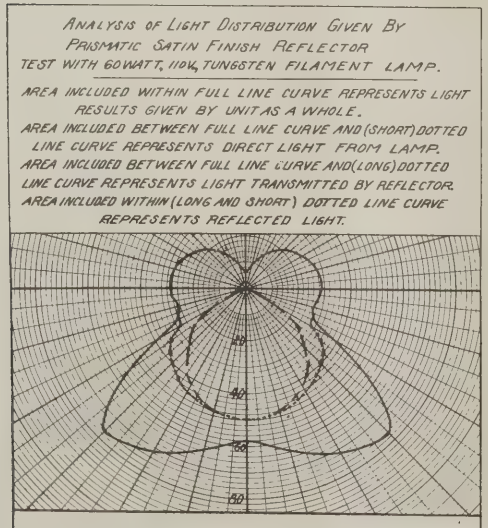

ANALYSIS OF LIGHT DISTRIBUTION GIVEN BY
PRISMATIC SATIN FINISH REFLECTOR
TEST WITH 60 WATT, 110V, TUNGSTEN FILAMENT LAMP.
AREA INCLUDED WITHIN FULL LINE CURVE REPRESENTS LIGHT RESULTS GIVEN BY UNIT AS A WHOLE.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (SHORT) DOTTED LINE CURVE REPRESENTS DIRECT LIGHT FROM LAMP.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (LONG) DOTTED LINE CURVE REPRESENTS LIGHT TRANSMITTED BY REFLECTOR.
AREA INCLUDED WITHIN (LONG AND SHORT) DOTTED LINE CURVE REPRESENTS REFLECTED LIGHT.
20
40
60
80

FIG 23

however, of sufficient magnitude to remove all cause for the objections brought out above. It may also be said that the values of Fig. 20, exactly as given, correctly represent a number of light density opal types at present on the market.

Fig. 19 represents typical distribution of a medium density opal reflector, the type here employed being much superior to the reflector of Fig. 20. Where ceilings are light colored, and the service requirements permit the use of an opal reflector, this type will give quite satisfactory results.

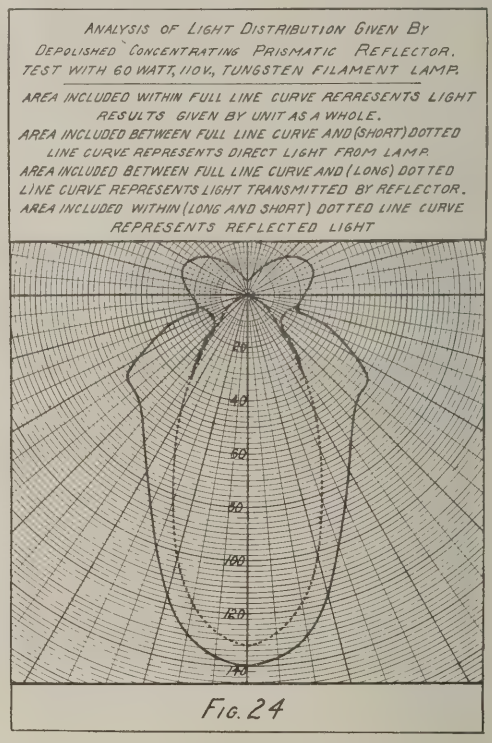

ANALYSIS OF LIGHT DISTRIBUTION GIVEN BY
DEPOLISHED CONCENTRATING PRISMATIC REFLECTOR.
TEST WITH 60 WATT, 110V, TUNGSTEN FILAMENT LAMP.
AREA INCLUDED WITHIN FULL LINE CURVE REPRESENTS LIGHT RESULTS GIVEN BY UNIT AS A WHOLE.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (SHORT) DOTTED LINE CURVE REPRESENTS DIRECT LIGHT FROM LAMP.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (LONG) DOTTED LINE CURVE REPRESENTS LIGHT TRANSMITTED BY REFLECTOR.
AREA INCLUDED WITHIN (LONG AND SHORT) DOTTED LINE CURVE REPRESENTS REFLECTED LIGHT
20
40
60
80
100
120
140

FIG. 24

It will be noted from the foregoing that the relative excellence of the different opal reflectors depends primarily upon the optical density of the glass and upon the whiteness of the reflecting particle, and not in the least upon any intrinsic differences in degree of light control afforded.

Fig. 21 presents the typical distribution given by a porcelain enameled metal reflector. The curve of reflected light shows how closely this type of reflector follows the Law of Diffuse Reflection.

Figs. 22, 23, and 25 show the light distributions given respectively by the satin-finished mirrored reflector, the satin-finished prismatic reflector and the aluminumized metal reflector, and illustrate the operation of the Law of Spread Reflection. The illustration in the case of the satin-finished prismatic reflector is not a particularly striking one. The reflector shape is one which, with a purely specular medium, gives concentration at 40° and also has a considerable tendency to give concentration at 5°. Now 40° is nearly mid-

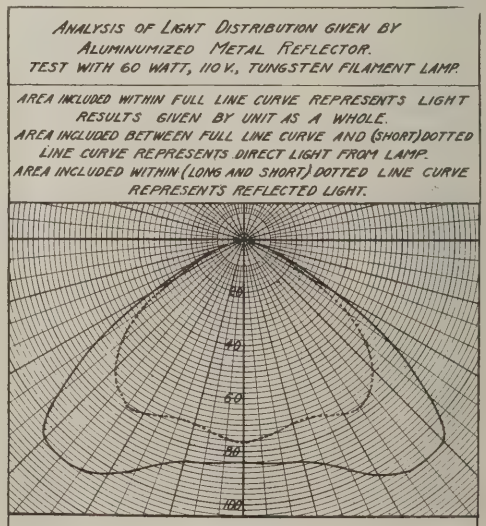

ANALYSIS OF LIGHT DISTRIBUTION GIVEN BY
ALUMINUMIZED METAL REFLECTOR.
TEST WITH 60 WATT, 110 V., TUNGSTEN FILAMENT LAMP.
AREA INCLUDED WITHIN FULL LINE CURVE REPRESENTS LIGHT RESULTS GIVEN BY UNIT AS A WHOLE.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (SHORT) DOTTED LINE CURVE REPRESENTS DIRECT LIGHT FROM LAMP.
AREA INCLUDED WITHIN (LONG AND SHORT) DOTTED LINE CURVE REPRESENTS REFLECTED LIGHT.
20
40
60
80
100

FIG.25

way between 0° and 90°. With concentration at such a comparatively high angle, the curve of reflected light tends to closely approximate to the curve which would be given by a diffusely reflecting medium. If the degree of concentration is as marked as that shown in Fig. 15, or more so, the candle-power falling off rapidly in either angular direction, the curve of reflected light will still show an appreciable divergency from that which would be given by a similar

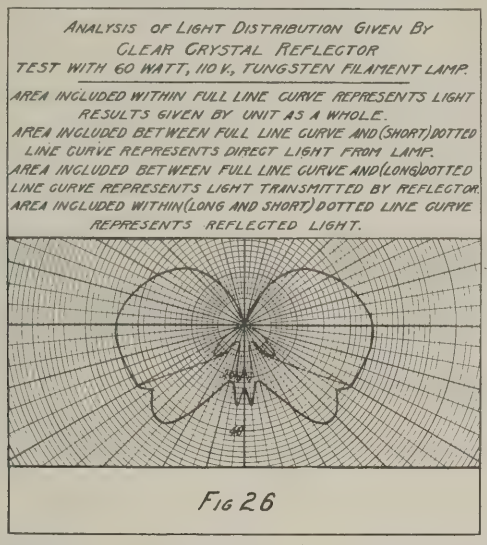

ANALYSIS OF LIGHT DISTRIBUTION GIVEN BY
CLEAR CRYSTAL REFLECTOR
TEST WITH 60 WATT, 110 V, TUNGSTEN FILAMENT LAMP.
AREA INCLUDED WITHIN FULL LINE CURVE REPRESENTS LIGHT RESULTS GIVEN BY UNIT AS A WHOLE.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (SHORT) DOTTED LINE CURVE REPRESENTS DIRECT LIGHT FROM LAMP.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (LONG) DOTTED LINE CURVE REPRESENTS LIGHT TRANSMITTED BY REFLECTOR.
AREA INCLUDED WITHIN (LONG AND SHORT) DOTTED LINE CURVE REPRESENTS REFLECTED LIGHT.
40
60

FIG 26

but diffuse reflector. But even such strong concentration as that shown in Fig. 16 is not sufficient to give a spread reflection curve differing appreciably from a diffuse reflection curve. In short, media obeying the law of spread reflection can afford a considerable degree of light control only when the corresponding specular media in the same reflector shape would give a very extreme degree of concentration at the desired angle.

The above facts are splendidly illustrated by a comparison of Figs. 23 and 24. Both figures show curves given by satin-finished prismatic reflectors. The two reflectors are of a different shape. The reflector of Fig. 23 is designed to give only a moderately strong concentration at 40°. The reflector of Fig. 24 is designed to give a very strong concentration at 0°. Thus both the angle at which the light is concentrated and the degree of concentration would cause the reflector of Fig. 24 to show the greater degree of light control after both reflectors have been satin-finished. This is strikingly the case. Fig. 24 shows that media obeying the Law of Spread Reflection belong to an essentially different and distinct class from media obeying the Law of Diffuse Reflection, even though the operation of the two laws, may, under certain conditions, produce practically identical results. No opal reflector ever has been or ever can be designed which will give anywhere near the degree of light control exhibited by the satin-finished prismatic reflector of Fig. 24.

The facts detailed above could also be established by curves from aluminumized metal reflectors. The aluminumized metal reflector of Fig. 25 shows an appreciably but yet not strikingly greater degree of light control than that given by the porcelain enameled reflector of similar shape (Fig.

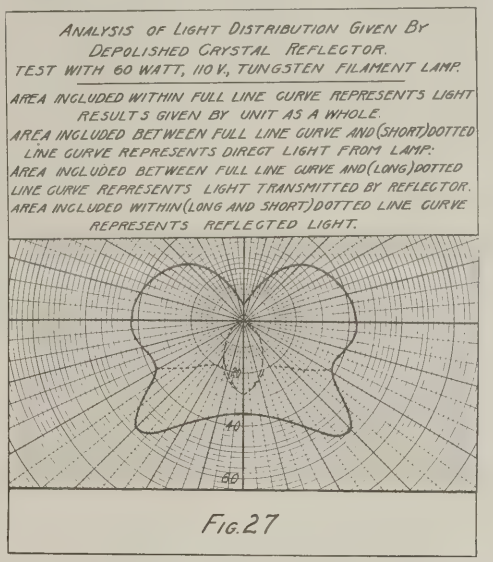

ANALYSIS OF LIGHT DISTRIBUTION GIVEN BY
DEPOLISHED CRYSTAL REFLECTOR.
TEST WITH 60 WATT, 110 V, TUNGSTEN FILAMENT LAMP.
AREA INCLUDED WITHIN FULL LINE CURVE REPRESENTS LIGHT RESULTS GIVEN BY UNIT AS A WHOLE.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (SHORT) DOTTED LINE CURVE REPRESENTS DIRECT LIGHT FROM LAMP.
AREA INCLUDED BETWEEN FULL LINE CURVE AND (LONG) DOTTED LINE CURVE REPRESENTS LIGHT TRANSMITTED BY REFLECTOR.
AREA INCLUDED WITHIN (LONG AND SHORT) DOTTED LINE CURVE REPRESENTS REFLECTED LIGHT.
40
60

FIG. 27

21). But aluminumized metal reflectors can be and in practice again and again have been designed to produce types of light distribution far beyond the reach of porcelain enameled reflectors.

Fig. 26 presents results of special interest to those approaching the subject of reflecting media from a scientific point of view. The figure shows the light distribution when a clear, smooth crystal form, identical in shape with that of the preceding reflectors, is employed. The curve of reflected light, the inside, dotted-line curve, is strikingly similar to that of the clear mirrored reflector (Fig. 15.) The shape of this curve of reflected light establishes the fact that the clear crystal form obeys the Law of Specular Reflection for such small amount of light as is reflected. The curve also shows how small in amount this reflected light is, and gives added proof that light specularly reflected from the glaze is never of sufficient magnitude to materially modify the light distribution of a diffusely operating reflector.

Fig. 27 shows the results given by the depolished crystal form, depolished, as in previous cases, on the inside only. This figure gives added proof that a depolished specular medium obeys the Law of Spread Reflection, not the Law

TABLE OF
REFLECTOR EFFICIENCY AND OF REFLECTION, TRANSMISSION, AND ABSORPTION VALUES.

TYPE OF UNIT	LUMENS			% OF INCIDENT LUMENS			% OF BARE LAMP FLUX			
	REFLECTED	TRANSMITTED	ABSORBED	REFLECTED	TRANSMITTED	ABSORBED	0°-50° ZONE	50°-100° ZONE	100°-180° ZONE	0°-180° ZONE
MIRRORED REFLECTOR CLEAR	373	——	58	87%	——	13%	71%	17%	——	88%
PRISMATIC REFLECTOR CLEAR.	208	145	72	49%	34%	17%	44%	29%	13%	86%
HEAVY DENSITY OPAL REFLECTOR, (WHITE IRIS) GLAZED	277	68	86	64%	16%	20%	52%	24%	7%	83%
HEAVY DENSITY OPAL REFLECTOR, (PYRO) GLAZED.	236	117	84	54%	27%	19%	46%	24%	13%	83%
HEAVY DENSITY OPAL REFLECTOR (PYRO) DEPOLISHED.							45%	23%	13%	81%
MEDIUM DENSITY OPAL REFLECTOR, GLAZED.	144	218	63	34%	51%	15%	33%	28%	27%	88%
MEDIUM DENSITY OPAL REFLECTOR, DEPOLISHED.							32%	29%	28%	89%
LIGHT DENSITY OPAL REFLECTOR, GLAZED.	80	275	52	20%	67%	13%	28%	31%	31%	90%
PORCELAIN ENAMELED REFLECTOR.	231	——	186	55%	——	45%	43%	20%	——	63%
MIRRORED REFLECTOR DEPOLISHED.	312	——	119	72%	——	28%	57%	19%	——	76%
PRISMATIC REFLECTOR DEPOLISHED.	122	243	60	29%	57%	14%	32%	33%	23%	88%
ALUMINUMIZED METAL REFLECTOR.	228	——	189	55%	——	45%	45%	17%	——	62%
BARE LAMP.	——	503	——	——	100%	——	13%	50%	37%	100%
CRYSTAL GLASS CLEAR.	33	383	15	8%	89%	3%	18%	48%	31%	97%
CRYSTAL GLASS DEPOLISHED.	34	377	20	8%	88%	4%	22%	42%	32%	96%

TABLE 1.

of Diffuse Reflection. A comparison of Figs. 14 and 27 emphasizes, in addition, the generally appreciated fact that etched crystal glass, generally known to the trade as C. R. I. shades, do not materially modify the distribution given by the bare lamp.

Table 1 presents an efficiency study of the results already shown by Figs. 15 to 27. This table will repay careful study It will here be sufficient to discuss only a few of the more important facts brought out by it.

The first feature that strikes the attention is the remarkable efficiency shown by the mirrored reflector, both in respect to the per cent reflected light and in respect to the per cent of light in the 0°-50° zone. These efficiency figures, while correct for the test reflector, are unduly favorable to the mirrored type and especially to the mirrored reflector of commerce. The efficiency of a mirrored reflector largely depends upon the perfect smoothness of the outside glass surface on which the silver is deposited. A practical mirrored reflector must have a corrugated or waved reflecting surface, in order to break up the highly objectionable images of the light source which would otherwise be produced. Such a corrugated reflector can only be made in a metal mold. The test reflector, however, was blown in a paste mold. Such a blown reflector really never touches the mold, being cushioned from the paste surface by a thin layer of steam. Hence such a paste mold reflector has much smoother outside surface than could ever be obtained in a metal mold reflector. This smoother outside surface, coupled with the absence of corrugations, gives about 10% added reflector efficiency. Yet even the mirrored reflector of commerce leads in efficiency all other types of reflector by a handsome margin.

It must not be forgotten, however, that the illumination given by the mirrored reflector, when such reflector is used as a direct lighting unit, is characterized by extreme lack of diffusion. This condition tends to produce reflected glare from the work, with resultant eye-inefficiency and eye-strain, and unfits the mirrored type for any service where long-continued, close visual work is done. Because of its limitations, the satisfactory application of the mirrored reflector is restricted to indirect lighting service and to highly specialized types of direct lighting service such as certain conditions of window lighting.

Another striking feature of Table 1 is the high efficiency shown by the special White Iris type of heavy density opal reflector, as compared with the prismatic reflector. The data here shown is apt to lead to very erroneous conclusions, and needs to be supplemented with other data.

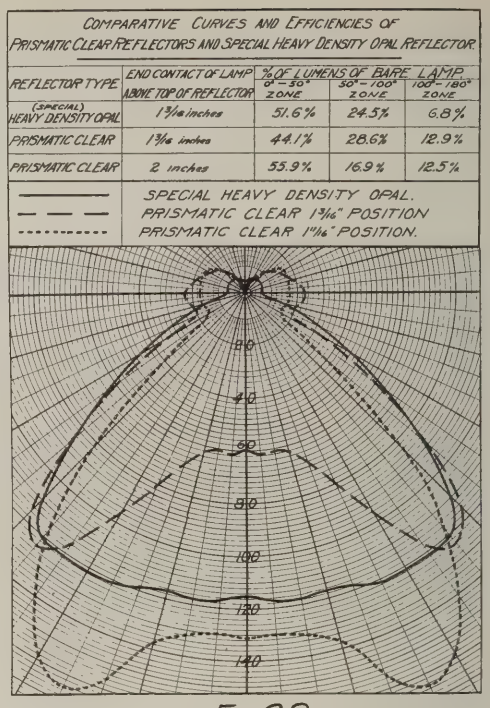


FIG. 28.

flector efficiency, so far as any differences in efficiency are possible. On the other hand, by employing a different prismatic reflector shape, the same type of curve as given by the special white Iris opal could be obtained at an illuminating efficiency increase of from 12% to 15% over that shown for the prismatic reflector in Table 1.

A partial demonstration of the fact above stated is afforded by a study of the changes in efficiency produced by changes in lamp position. Such a study for the reflector shape here employed is given in Table 2. In analyzing this table it should be remembered that, under average illumination conditions, all the light emitted in the 0°-50° is useful for illumination; 13% of the 50°-100° light is useful; and 35% of the 100°-180° light is useful.

TABLE SHOWING
EFFECT OF LAMP POSITION ON EFFICIENCY
IN THE FOUR SIGNIFICANT ZONES.

END CONTACT OF BASE OF LAMP ABOVE TOP OF REFLECTOR	PERCENT OF BARE LAMP FLUX											
	0°–50° ZONE			50°–100° ZONE			100°–180° ZONE			0°–180° ZONE		
	PRISMATIC CLEAR	SPECIAL HEAVY DENSITY OPAL	MEDIUM DENSITY OPAL	PRISMATIC CLEAR	SPECIAL HEAVY DENSITY OPAL	MEDIUM DENSITY OPAL	PRISMATIC CLEAR	SPECIAL HEAVY DENSITY OPAL	MEDIUM DENSITY OPAL	PRISMATIC CLEAR	SPECIAL HEAVY DENSITY OPAL	MEDIUM DENSITY OPAL
7/16 inch	32.6	46.3	30.2	41.0	30.2	34.2	13.7	6.4	24.3	87.3	82.9	88.7
1 3/16 inches	44.1	51.6	32.6	28.6	24.5	28.0	12.9	6.8	26.8	85.6	82.9	87.4
1 1/16 inches	52.1	54.3	33.8	21.3	21.1	25.4	12.7	7.2	28.2	86.1	82.6	87.4
2 inches	55.9		33.6	16.9		23.1	12.5		28.8	85.3		85.5

TABLE 2.

It has long been well-known by authorities in reflector design that the so-called Extensive type of light distribution, as exemplified by the curves of Fig. 8, cannot be produced at the same efficiency as can more concentrating types of distribution. This comparative inefficiency arises from the fact that the Extensive distribution cannot be produced, since the light source is not a point source, without involving an undue amount of multiple internal reflections. On the other hand, the Extensive type of distribution is absolutely required under certain quite general conditions of service, if entirely satisfactory illumination results are to be obtained.

The particular type of reflector employed in these tests was chosen in order to establish the fact that a true Extensive type of light distribution can be obtained from prismatic or mirrored reflecting media, but can not be obtained from opal or porcelain enameled media. The curves already presented have well established this fact.

As has already been shown, changes in shape of reflector do not materially affect the character of light distribution nor the efficiency of any opal type. As for efficiency, the shape here employed is the one most favorable to opal reflector efficiency, so far as any differences in efficiency are possible. On the other hand, by employing a different prismatic reflector shape, the same type of curve as given by the special white Iris opal could be obtained at an illuminating efficiency increase of from 12% to 15% over that shown for the prismatic reflector in Table 1.

Keeping these figures in mind and referring to Table 2, it will be noted that the illuminating efficiency of the special White Iris Reflector is affected to only a small degree by changes in lamp position. The medium density opal reflector is affected practically not at all. The prismatic reflector, however, shows large and well-balanced variations in illuminating efficiency as between the successive lamp positions. As the greater degree of concentration is reached, the prismatic reflector forges ahead of the special heavy density opal, in spite of the fact that the prismatic reflector shape is not such as to give best possible efficiency for this type of medium.

Fig. 28 shows part of the same data in graphical form. It emphasizes the great change in both type of light distribution and efficiency which occurs in the prismatic reflector with change of lamp position.

This phase of the subject may be summed up by stating that, in the present state of the art, no opal reflector can be designed to give within 10% as high illuminating efficiency as a prismatic reflector of similar type of light distribution; and such highest efficiency values on the part of the opal

reflector can only be obtained at a sacrifice of the diffuseness of illumination, as compared with the illumination given by the prismatic reflector.

The great range in reflecting efficiency and in illuminating efficiency which characterize the opal type of reflector is well shown by Table 1. When the walls and ceiling, or even only the ceiling, are very light in color, the lower absorptions of the lighter density opals in part compensate for their lower reflecting values, and the illuminating efficiencies as between the various opal types, do not so widely differ. Under normal installation conditions, the best medium density opal reflectors to-day on the market exhibit somewhat higher illuminating efficiency than the average heavy density opal reflector and not very greatly less than the White Iris heavy density opal. But under average installation conditions, and still more when the ceiling is darker colored than the average, the light density opal reflector shows up very unfavorably in illuminating efficiency.

Table 1, presenting as it does the important differences which exist between the different types of opal reflectors, strongly emphasizes the need of a broader technical knowledge than is at present being generally brought to bear on the subject of opal reflector design and in the choice of opal reflectors for service.

The fact that, in the deep bowl shape, porcelain enameled reflectors and aluminumized metal reflectors have almost identical efficiencies is brought out by Table 1. The porcelain surface has, for a single reflection of the light, a considerably lower absorption than the aluminumized surface; but the excessive multiple internal reflections, unavoidable in a reflecting medium like porcelain which obeys the Law of Diffuse Reflection, bring the efficiencies of the two reflectors to the same level. Comparisons made with a more shallow type of reflector would, of course, be more favorable to the porcelain.

It will be noted from Table 1 that even such a poor type of reflector as the light density opal is still a great improvement over the bare lamp.

Summary.

The practical conclusions to be drawn from the above technical presentation of the laws governing reflection and reflecting media may be summarized as follows:—

1. The various types of reflecting media extensively employed in service should be grouped as follows:

Reflecting Media following the Law of Specular Reflection.

Clear Prismatic Reflectors, Mirrored Reflectors, Polished Metal Reflectors.

Diffuse Reflection.

Opal or White Glass Reflector, all types, Porcelain Enameled Reflectors.

Spread Reflection.

Satin-finish Prismatic Reflectors, Aluminumized Metal Reflectors.

2. Wherever distribution requirements call for Extensive, Focusing or Concentrating types of light distribution, as in many cases of office lighting, all cases of window lighting, etc., etc., reflectors of specular or at least of spread media should be employed.

3. In the many cases where distribution requirements call for the Intensive type of light distribution, properly designed opal reflectors can satisfactorily be used, the illuminating efficiency being from 10% to 30% lower than that of the proper type of clear prismatic reflector.

4. Light density opal reflectors should not be used where efficiency is of importance or where long-continued, close visual work is to be performed.

5. Bare lamps should never be used. There are practically no conditions of service where the savings in current consumption made possible by the use of a reflector will not pay for the cost of the reflector.

6. In the bowl shape of reflector, which good practice will usually require in average conditions of service, the aluminumized metal reflector has equal illuminating efficiency with the porcelain enameled. This, added to other considerations not here presented, makes the aluminumized metal the decidedly preferable type of reflector.

In conclusion, the author begs leave to call attention to the great practical need for a more general understanding of the considerations and laws which form the subject matter of this paper. The subject is necessarily somewhat technical, and this may serve to discourage the interest of practical men,—the men who are directly responsible for a large proportion of our lighting installations; but until the facts here presented are more generally applied to practice, society will continue to sustain a considerable economic loss, and an unnecessarily large number of cases of impaired vision.

The author desires to express his indebtedness to the Engineering Department of the Holophane Works of the General Electric Company for the considerable amount of test work required in preparing this paper, and to the National X-Ray Company for generously furnishing the mirrored reflectors.

Motor Talk No. 4

COMPOUND WOUND MOTORS.

Compound-wound motors form the third general class of d. c. motors and display many of the characteristics of both series and shunt-wound machines. Compound-wound motors take their name from the fact that there are two sets of coils in the field-windings, one set connected in series with the armature and the other directly across the line.

The action or effect of these two sets of windings is just as has been explained when describing the shunt and series motors in the preceding articles. The shunt coil is across a line of constant potential, or voltage, so the field strength will be constant and the speed constant unless deliberately varied. But, the series coils are connected so that their strength is varied by the amount of current passing through the armature, and this naturally causes the speed of the motor to vary some.

So, it is customary to so design compound wound motors that the proper relative strength is produced by each set of coils. The speed of compound wound motors varies more with the load than it does in the case of plain shunt wound motors, unless the motor is especially

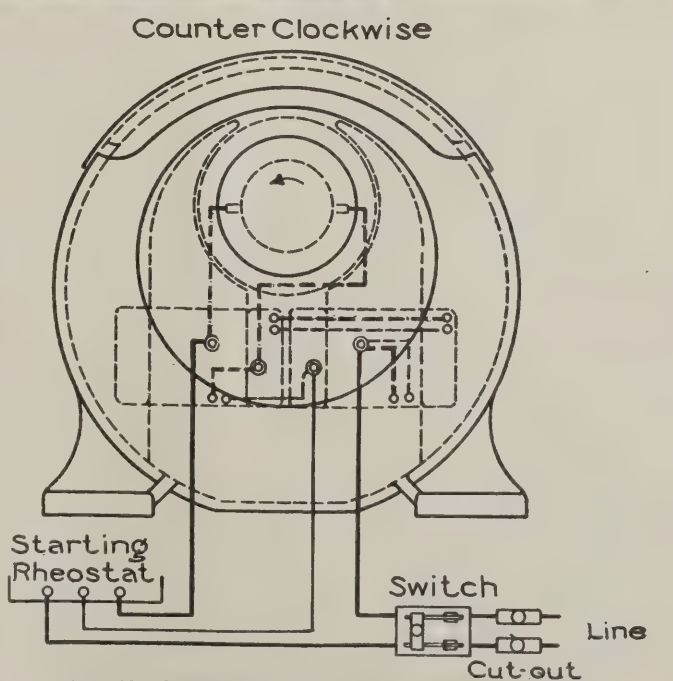


Fig. 16. Connections for Bi-Polar Compound Motor.

designed to compensate by increasing the number of turns in the series coils in such a way that the speed tends to rise with the load. This is called "over-compounding," and can be done so that the speed is constant at all loads and still give the advantage of strong torque at starting as with plain series motors.

The speed or compound wound motors can be either increased above normal or reduced below normal by

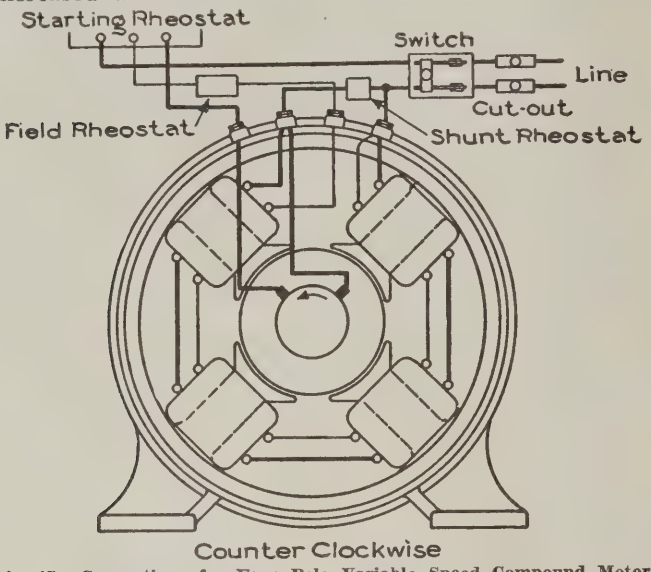


Fig. 17. Connections for Four Pole Variable Speed Compound Motor.

means of resistances in series with the windings. To increase the speed above normal you must weaken the field strength by placing resistance in series with the shunt field winding, thus allowing the reaction of the armature on the field to increase. Very little energy is lost by this method because the current flowing through the shunt field coils is so small, and the energy loss in watts is equal to the square of the current multiplied by the resistance.

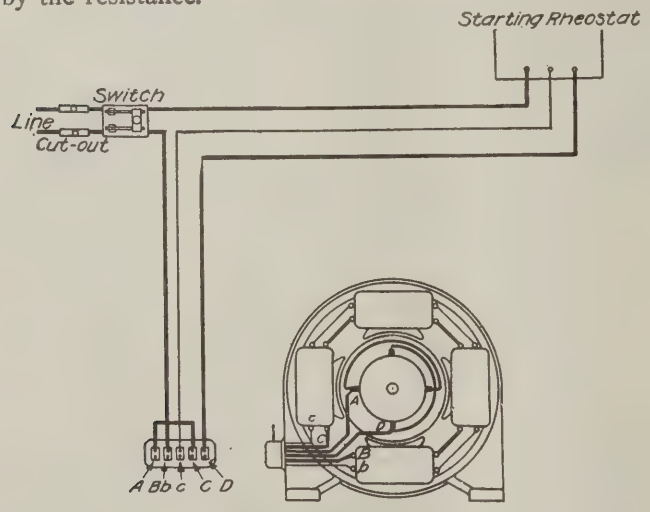

Starting Rheostat
Switch
Line
Cut-out
A Bb c C D
A and D are Armature Terminals
B and C are Series Field Terminals
b and c are Shunt Field Terminals
Motor Connected for Counter Clockwise Rotation
For Clockwise Rotation interchange external connections to A and D at the Terminal Block

Fig. 18. Four-Pole Compound Motor with Connection Board.

To reduce the speed it is necessary to insert resistance in series with the armature (and series field) in order to reduce the amount of current flowing by cutting down the voltage. In this case the loss of energy is considerable because the armature current is comparatively large. But where wide variations of speed are required the efficiency is generally of less importance than results. With either field or armature control alone the range or variation is limited to about four to one, but with a combination of the two you can get variations of seven or eight to one with properly designed motors. In fact, some manufacturers make motors giving a variation of 30 to one.

Another form of compound motor has been made for six or eight years which has extra pole-pieces between the main poles. These "inter-pole" motors have shunt

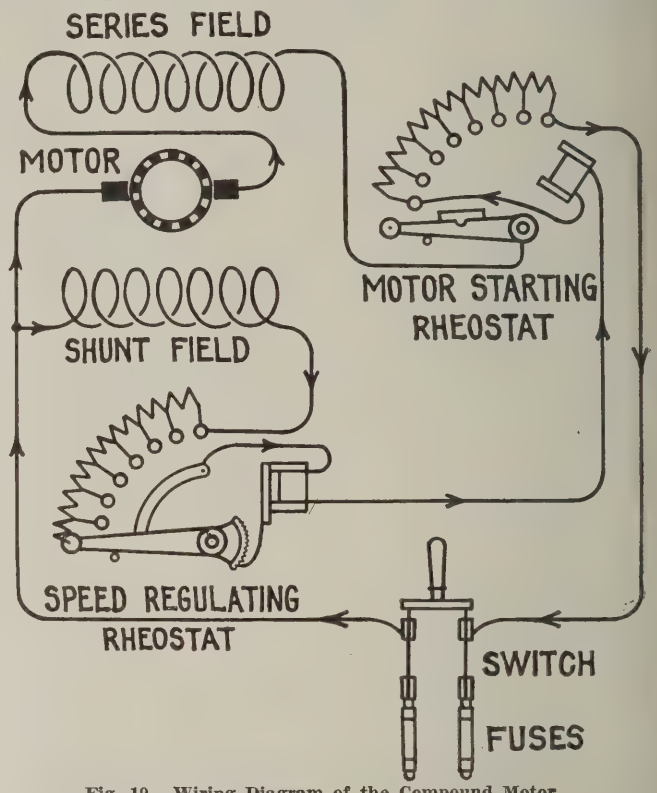


Fig. 19. Wiring Diagram of the Compound Motor.

connected windings on the main poles and series connected windings on the inter-poles. The object of this is to reduce sparking at the commutator, and it is done by producing a magnetic field independent of the main field of the motor, suitable in strength and location for proper commutation under all conditions of load and speed.

The action of these extra, or "commutating poles," is very simple. They generate an e. m. f. in the short-circuited coils of the armature of the proper value to arrest the current and reverse it in the coil while the terminals of the coil are passing under a brush. In other words, this voltage must just balance the reactive voltage of the armature coil. This gives a machine which can be operated as either a motor or a generator, for either direction of rotation, without shifting the brushes or changing the connections, other than reversing the armature connections to reverse the direction of rotation. That is why motors of this type are so superior to any other kind for driving machine tools, and generators of this type will run at anything between quarter load and twenty-five per cent over-load without sparking, and require no shifting of the brushes. There are one or two other forms of compound machines made, but they are so seldom seen that they are worth no description here.

The Question Box.

Dec. 19, 1912.

The Question Box,
Editor Shop Motor Section,
Dear Sir:

In the December number of your paper you show on

page 220 a set of curves for a 45 h. p. motor. Will you please explain what these curves mean?

In different books I have been reading and in the magazines, I have seen a good many curves but have never seen any explanation as to how to read them. It might be a good idea to answer this in the next issue of your paper. H. T. F.

Answer—Curves are very easy to read when you once understand how and can be made to show a great many things much better than tables or other lists of figures. They also show the relation between different things a great deal better than tables. Perhaps the best way to get a clear understanding of how to read curves would be to take something familiar and show in the form of a table and also as a set of curves.

Herewith we show an ordinary multiplication table with which you are, no doubt, already familiar. This table shows a complete set of tables, from 1 to 12, in the form of a single chart and you can easily understand

	1	2	3	4	5	6	7	8	9	10	11	12
1	1	2	3	4	5	6	7	8	9	10	11	12
2	2	4	6	8	10	12	14	16	18	20	22	24
3	3	6	9	12	15	18	21	24	27	30	33	36
4	4	8	12	16	20	24	28	32	36	40	44	48
5	5	10	15	20	25	30	35	40	45	50	55	60
6	6	12	18	24	30	36	42	48	54	60	66	72
7	7	14	21	28	35	42	49	56	63	70	77	84
8	8	16	24	32	40	48	56	64	72	80	88	96
9	9	18	27	36	45	54	63	72	81	90	99	108
10	10	20	30	40	50	60	70	80	90	100	110	120
11	11	22	33	44	55	66	77	88	99	110	121	132
12	12	24	36	48	60	72	84	96	108	120	132	144

Fig. 20. Multiplication Table as Numbers.

that. If you want to multiple 6 by 8, you simply find 6 at the left and read right across to the column which has 8 at the top and you find the answer (48); or if you want 11 multiplied 12 you can find 11 at one side and the answer (132) in the column with 12 at the top, etc.

This same table is shown as a set of curves herewith and it is handled in very much the same way. For instance, in order to find out 6 x 8 you start at 6 at the bottom of the curve sheet, run your finger up to the curve or diagonal line for the table of 8's, and then run your finger over to the right where you find the answer (48); or if you want to multiply 11 by 12, find one of the numbers at the bottom and then run up to the curve of the other number and you will find the answer at the right. The same applies, of course, to any combination of figures.

Referring to the curves for the 45 h. p. motor, which is reproduced herewith, you will note that this shows a good many different things, but it is just as easy to read. First, of course, you should understand that in determining the efficiency or capacity or other characteristics of electrical machinery the matter is always considered from the standpoint of power required. Since practically all electrical distribution systems operate on constant voltage it is customary to determine the power consumed in terms of amperes. Therefore, curves are usually made up with amperes as the common factor and these are usually, but not always, indicated at the bottom of the chart, as in this case.

In order that any set of curves can be made to indicate anything there must be at least 2 factors so that it will read in 2 directions, to and from the curves, the same as the multiplication table. Take, for example, the curve of efficiency. This is usually stated as a percentage of perfection, which would be 100%. If you will start at 40 amperes at the bottom and run up to the efficiency curve you will find the efficiency to be 90%, as indicated at the left. Or take the line indicating full load, which in this case is 68 amperes, and run up that line until you strike the efficiency curve, where you find that it is also 90%. This curve indicates that the efficiency

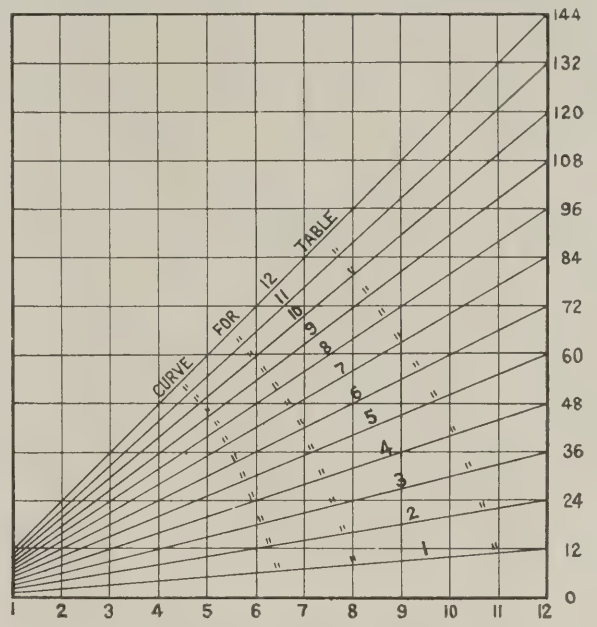


Fig. 21. Multiplication Table Plotted as Curves.

of the motor is practically constant from about ½ load up to full load, and a little beyond, beause the efficiency curve is alomst flat within those limits. On the other hand if you will take it at 10 amperes the efficiency shows to be only 70%

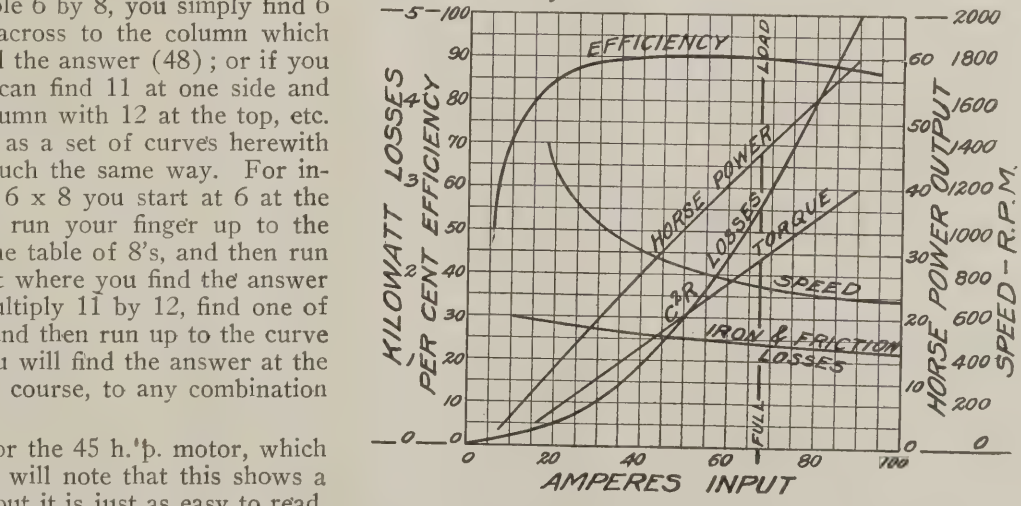


Fig. 22. Characteristic Curves for a 45 h. p. 750 r. p. m. Series Railway Type Motor.

Now take the curve marked horsepower and you will find that the h. p. output, as indicated at the right, is 45 h. p. where the h. p. curve crosses the full load line. Take the current at 60 amperes and run up to the h. p. curve and then over to the right and you will find that the output is 40 h. p. It is sometimes important to know what the h. p. output would be in order to use the motor operating at different speeds. Taking the line indicating full load, which is 68 amperes, and running to the speed curve and then over to the right, to the column indicating speed as revolutions per minute, shows the full load speed to be about 750 r. p. m.

If you want to find the speed with 40 amperes flow-

ing you start at the 40 ampere mark, run up the speed curve and cross to the right and find the speed to be 900 r. p. m. By taking the 40 ampere mark and running up the h. p. curve you will find that the h. p. at 40 amperes and 800 r. p. m. is about 26½, because that is the value given at the right of where the h. p. curve crosses the 40 ampere line.

Sometimes it is desirable to know the internal losses of the motor. In that case you can determine the losses at any current you desire by starting at the bottom and running up to the curve labelled "C^2R Losses" and then over to the left, reading the number in the column labelled "Kilowatt Losses." For instance, suppose you want to know the watts lost when running on 40 amperes. Begin at 40 below, running up to the loss curve over to the left, and you find that it is 1 k. w. If you will continue on the 40 ampere line to the speed curve you will find the speed at this loss. Again, if you want to know the loss at full load, strat at 68 amperes and then run up to the loss curve and over to the left, and you will find it to be 2¾ k. w or 2,750 watts.

Having curves of this kind you can easily compare the actions of two motors, by simply taking the two sets of curves applying to those motors and reading as above indicated. You can also determine various other relations which you will easily see by the chart. Curves are very valuable and are one of the most useful inventions the electrical man has to deal with, and it is worth any man's time to sit down and learn how to read curves as they are being used more and more all the time as a means of expressing facts, which used to be shown by columns of figures only, and which were not nearly so easy to understand. G. W. C.

COMMUNICATION ON HEADLIGHT TESTS.

To the Editor:—

I am in receipt of your publication for November ,and am very much interested in the tests made by the Railroad Commission of Wisconsin, and the meeting held in Chicago on October 15th, before the Western Railway Club.

It seems strange, indeed, that if it is facts they wish in these cases, that they do not try to secure some practical and competent men to assist in these tests. How do they know that some of the men selected to make these were not spasmodically color blind. It would seem that way, by some of the results obtained.

I have been riding behind Engines, equipped with Electric Headlights, for the past 17 years, also, have gone into this matter very thoroughly, as we intend to present a bill, to the next general assembly of the State, asking for a better headlight. I have used these lights on both single and double track roads, and have never heard of any engineer mistaking a signal, nor do I know of any engineer, who ever run an engine with an electric headlight, who would wish to go back to the oil lamp; but, on the contrary, I have a desk full of testimonials from our engineers, who ask for them, and say they do not change the colors of signals, if properly focused. I know as well, and all should know, that the oil lights are no earthly use to Engineers, so far as seeing things are concerned, but I do know, and have the proofs of it, that the Electric Headlight has saved some very bad accidents, which would, no doubt, have resulted in great loss of life. One of these, on a system that has spent $100,000 perhaps, for electric headlights, saved this sum, in one case alone, when eight cars were blown out of a siding and went down into a sag, and their East bound Limited, loaded with passengers, running at a speed of at least sixty (60) miles an hour, would have crashed into these cars but for the electric headlight. Fortunately, the engineer was able to see these cars, by the aid of the powerful light, in time to stop before hitting them thereby saving what would have been a very serious wreck, no doubt, and certainly, very poor advertising for that railroad.

If Railway Commission want facts, why do they not select men who are competent to make these tests; men, whose eyes are trained for this work. How many of them could get down and put in a fire, then get up and see a signal light, let alone the color of it? still our firemen do this night after night.

If Uncle Sam built a dreadnaught, would he be showing good judgment, to man this ship with college professors and students and send them to do battle with the enemy? You could expect but one result. You would not like to ride across this country, and depend upon some professional man to run the engine, no matter what book learning he had, when you were going sixty or seventy miles an hour. No, you would rather trust yourself to the eye that is trained to the work would you not? If your watch needed repairing would you call in a blacksmith? If your teeth required filling would you call a plumber? You might just as well as to call on a college professor, with his untrained eyes, to come out and make a series of tests, and tell you what is best for the locomotive engineer.

Do they know there are electric headlights made right here, in Chicago, that do not blind the Engineer? Do they know that we do not get good results by having a light that shows us the ears on the corn in the field? We wish the light to show us the conditions on the track.

They speak of the Banjo signal, well, that is obsolete and as much out of date, as a pump on a modern engine; no earthly good in a snowstorm, and very poor, at their best, for high speed trains. Look over the accidents to the eighteen hour trains since they were put on; do you doubt, in the least, that some of these could have been prevented, if the engineer could have seen the conditions ahead of him? Do you know you can stop a train going sixty (60) miles an hour in eleven hundred (1100) feet with the new high speed brake?

Some of our railroad officials have fought every improvement ever devised for the safety of their trains, but, after they were compelled to equip them with these appliances they should not be compelled to part with them.

If the Railway Commission of Wisconsin or any other State wishes to get at the facts of this case let them come up, and go over my files with me, and I believe, I can convince any unbiassed mind that the professors of the Universities are in the wrong, and that the electric headlight is a life and property saver, and absolutely next to the airbrake, the best invention ever placed on a train. As to its changing the color of signals, that is all "Bosh."

Your truly,

J. A. CULP,
Chairman State Legislative Board Brotherhood of Locomotive Engineers.

INDUSTRIAL ILLUMINATION.

At the December meeting of the Chicago Section of the Illuminating Engineering Society, Mr. Ward Harrison of the National Electric Lamp Association, Cleveland, Ohio, presented a paper on "Industrial Lighting."

In opening the paper he outlined in a general way the progress of industrial plant illlmination and said that in this class of illumination, the engineer knew at least exactly what results were desired. He said that the spacing distance of any type of light with practically any of the commercial reflectors should not be more than twice

the height above the illumination plain. He said that a spacing of 1.6 times the height provides uniform illumination, but where the spacing is greater than twice the height the nonuniformity becomes objectionable. He said that ¼ ft. candle can be taken as a minimum value of illumination in any part of the plant. Below this value the inability of the eye to see clearly is liable to cause accidents. As a maximum value of illumination, this should never be more than 40 to 50 ft. candles; and such instances are usually found on sewing machines, in watch-making, etc., where a spotlight illumination is employed. Probably over 95 per cent. of the installations vary between 1 and 6 ft. candle intensity.

On the subject of glare, he said that placing a diffusing globe around a lamp does not reduce the glare in so far as ability to see is concerned. It does, however, materially reduce the ocular discomfort caused by looking at a light of high intrinsic brilliancy. He said that no light source should be in the field of vision; that the illumination should be nearly uniform so that there may be no strong contrast, etc., and that the lamps should be so placed as to avoid specular reflection of stationary objects.

It usually pays to light a room well. This gives a wide awake appearance to a shop or factory under which the employees can work almost the same as under daylight conditions. If a man can save 30 seconds an hour he will more than save the entire cost of lighting.

As to operating costs, however, he said that the use of an illuminometer in determining the relative merits of lighting systems, by which they were figured as so many lumens per dollar, has undoubtedly been greatly overdrawn. Other considerations enter into the problem which are fully as important as the amount of light or cost of production. The chief of these is the effect of the illumination upon the human eye; or, in other words, eye efficiency must be given due consideration.

In regard to flickering of tungsten lamps on a. c. circuits, he said that with 25 cycles, a 60 watt lamp is the smallest size that can be used without any appreciable flicker. The use of smaller size lamps on 25 cycles should be avoided.

On the subject of ventilated reflectors or blackening of lamps in reflectors that are not ventilated, Mr. Harrison stated that inasmuch as the temperature of the tungsten is between 2000 and 3000 degrees C., while the temperature of the reflector is between 30 and 40 degrees C., and might even under worst conditions rise to as high as 50 or 60 degrees, this slight increase in temperature, possibly due to the heating of the reflector, would not influence the temperature of the filament to the slightest degree. Numerous tests on this point proved the correctness of this assertion. He said that series burning of lamps in a cluster should be discouraged, the lamps cost more and there is no advantage gained thereby.

The author then showed some interesting diagrams on the depreciation of the various types of reflectors in service: the porcelain enamel, prismatic clear and opal glass. All reflectors depreciated rapidly during the first week, but after that the decrease in efficiency was more gradual. At the end of 40 weeks the enameled reflector had dropped to an efficiency of 80 per cent. of its original value, the prismatic clear to 68 per cent., and the opal to 63 per cent. He said that with both opal and prismatic about one-half of the lost efficiency seemed to come from the collection of dust on the outside of the lamp and the inside of the reflector, and the other half of the loss from the dust collected on the outside of the reflector. He said that aluminized reflectors collect dirt more rapidly than enameled steel.

He also called attention to the fact that mirrored glass reflectors seem to have a wide application in industrial work, for they retain their high efficiency very much as the enameled steel reflector does, since the collection of dust on the outside of the reflector has no influence in reducing its efficiency.

In certain cases where fumes or corrosive gases are objectionable, such as in roundhouses, he suggested that an asbestos ring soaked in water glass be placed over the lamp before it is screwed into the reflector. This will then make an air tight joint between bulb and reflector, covering the brass work in the socket and in the base of the lamp.

There is a slight variation in the color of porcelain enameled reflectors and inasmuch as the light from an incandescent lamp is stronger in red and yellow rays than it is in blue rays of the spectrum, a reflector which has a slightly yellowish cast will give an efficiency of 10 or 15 per cent. higher than one which has a blueish cast. This is obvious, for a yellow reflecting surface will reflect yellow rays and absorb the blue, while the blue surface will reflect the blue rays and absorb the yellow, and where yellow rays predominate in the source of light the efficiency will be higher when the reflector has a yellow cast.

When the reflector is of a slightly grayish cast it may easily reduce the efficiency 10 or 15 per cent. inasmuch as the black particles of the enamel are of very low reflecting value.

The author showed lantern slides of an installation with layout of units, curves of test, etc., and gave data on one particular installation where there were 100 men employed . The lighting cost 15c. per hour, while wages paid men were $25.00 per hour. In other words, if the men could save but 30 seconds per hour through having good light to work by, that saving would pay for the entire cost of lighting.

He then showed the detail of an installation of angle type reflectors in open hearth steel mills. Although these units only deliver about 70 per cent. as much useful light as the standard bowl type, they have been adopted as a standard unit for this service.

In discussing this paper, Mr. H. G. Wheeler referred to the use of mirrored reflectors in industrial lighting and showed a few slides of some effective installations of this type.

ADDITIONS TO VICTOR-BALATA PLANT.

It is the exception rather than the rule that manufacturers are compelled to increase their production facilities during the year of a Presidential election. Heretofore the general rule has been to curtail expenses and await the immediate developments following a change of administration and consequently a change of policy.

While business in general during the past six to eight months has been hardly more than normal, it is a matter of considerable gratification to the Victor-Balata & Textile Belting Co., of New York City and Chicago, with factories in Easton, Pa., to be compelled to build additions with added machinery to its already large textile factories where Victor-Balata belting is made.

It is generally well known that increased facilities, more machinery, etc., have been forced by the rapidly increasing demand for Victor-Balata belting since it has been made in America, and the many friends of the company will be pleased to learn of the much-needed factory increase, now in the course of construction, in the canvas-stitching belting department to accommodate the expanding trade in this particular line.

LESSON NO. 12.

B. & O. Head End System.

In our November and December lessons we have taken up the C., M. & St. P. Ry. system and the Harriman line system for head-end trains. You will recall that in the first of these the battery was charged by opening the rear loop and feeding the lamps from the forward end of the train through a resistance. This makes it possible then to raise the generator voltage to any desired value in charging the battery, while the lamp voltage can be maintained constant by the rheostat.

The second system of the Harriman lines, the generator voltage is maintained constant at all times and in charging the battery is cut in two and the two half batteries (each of but half normal voltage) are then charged through a resistance.

We review these two other systems briefly so that you will appreciate the difference between them and the B. & O. System we take up in this lesson. With this system a lamp regulator is placed on every car in the train and this regulator maintains constant voltage on the lamp circuit even though the voltage on the train line be raised 15 or 20 volts above normal in charging the battery.

The wiring diagram for train line and car circuits is shown herewith, and it will be noticed that some of the cars carry batteries while others do not. As a matter of fact, it is the usual practice to have five cars equipped with storage battery of 300 ampere hour capacity on a train of seven cars. These batteries are connected between the two outside wires of the train line just as the lamps are, so the rear battery receives practically the same charging voltage as the first battery.

come directly on the lamps for the lamp voltage in each car is controlled by its own lamp regulator.

It has been found that there are so many unforseen conditions to be met, such as broken steam connectors

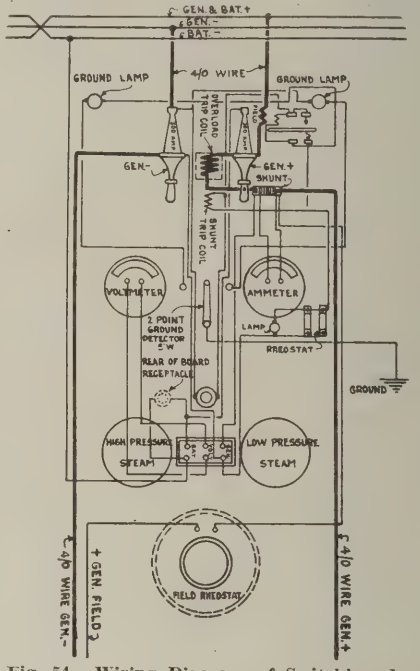


Fig. 54. Wiring Diagram of Switchboard.

or steam failure from other causes resulting in preventing the operation of the turbine for a considerable part of the run, that it is necessary to keep the batteries in as nearly a fully charged condition as possible. As a matter of fact, even under normal conditions 15 to 20 per cent.

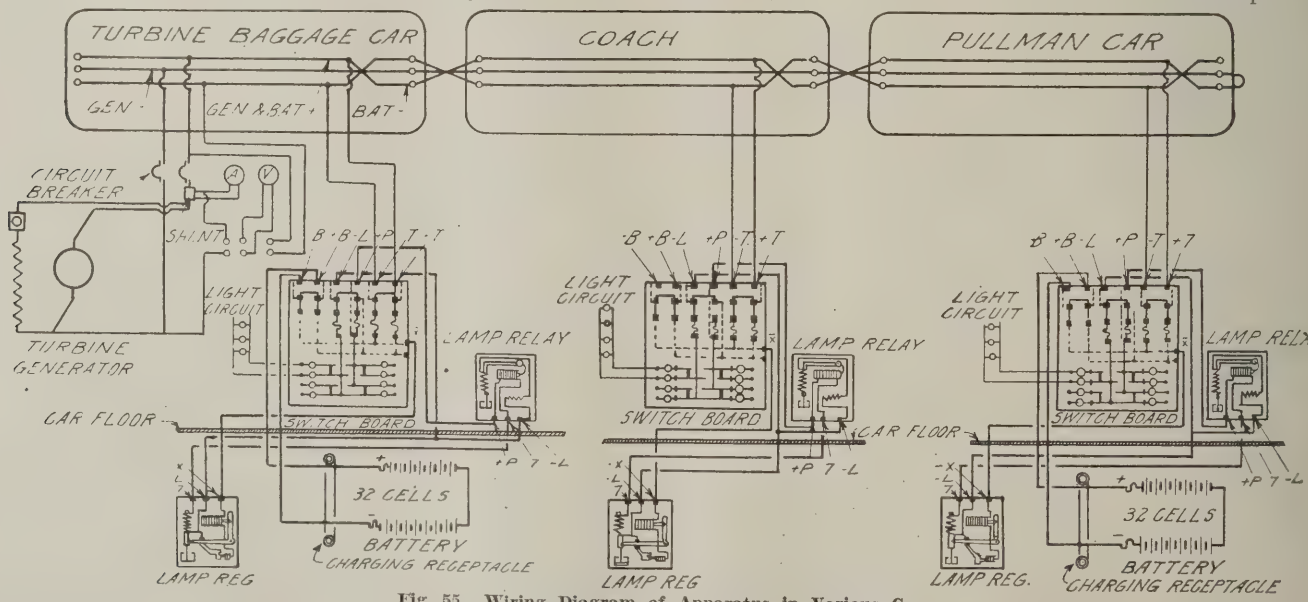


Fig. 55. Wiring Diagram of Apparatus in Various Cars.

The B. & O. head-end system operates at 63 volts, although generator voltage may vary anywhere from 70 to 90 volts, depending upon the battery charging voltage required. This variation in voltage, however, does not

of the lighting hours it is necessary to depend on the battery. On several occasions the turbine car has been cut out of the train in the early part of its run, and the lighting for the balance of the trip carried by the bat-

teries without failure. Frequently battery cars are transferred to some other division or road for a considerable length of time, resulting in complete discharge of the battery and, in many instances, severe cases of sulphation. Instructions are issued to charge these batteries independently of the rest of the batteries in the train until

Fig. 56. View of Turbine and Switchboard.

they are sufficiently charged, when they can then be connected on charge with the other batteries.

These and other conditions make it difficult to lay down any hard, fast rule pertaining to charging batteries, and it will be well for the head-end electrician taking this course to study over pretty carefully the lessons in April, May, June and July on storage batteries.

It is always better for a man to use his good judgment intelligently, provided he understands the characteristics of a storage battery, than it is to follow any definite rule.

The log of a trip given in Fig. 57 shows some of the conditions and how the batteries were kept in a charged condition.

This, by the way, is a sample of the record kept of each trip by one of the B. & O. electricians for his personal use. He carries a small pocket note book which is ruled off as shown and the entire record of each round trip is given on the front side of one sheet with remarks of trouble, ampere hour meter readings, etc., given on the back. This makes a personal record covering several months which can be referred to at any time desired. There is another advantage in keeping such a record as this, in that a man will know more definitely what amount of charge he is giving storage batteries on his train.

The voltage of the storage batteries is taken both before and after each charge, and these readings are taken with the storage batteries carrying the lamp load. Never take a voltage reading on open circuit (no discharge), for even a low battery may give a fairly high voltage if there is no discharge current flowing. Always let the battery discharge on full load for two or three minutes before taking the voltage reading.

If the voltage is below 64 volts, (2 volts per cell with 32 cells per battery) it would indicate that battery is somewhat low and needs a charge. If it is daylight and no lights are on, the generator voltage should be raised until the charging current amounts to about 30 amperes per battery. This with 5 batteries per train would

TRAIN & DATE	DEAD CARS	BATTERIES	STARTING TIME	VOLTAGE	STOPPING TIME	VOLTAGE	HOURS RUN	AMP'S ON START	½HOUR LATER	AMP'S ON STOP	STEAM
5 10-5	2	5	2:00 P.M.	67	3:00 P.M.	70	1	165	120	120	110 110
5 10-5	2	5	3:30 P.M.	66	4:45 P.M.	69	1¼	150	100	100	110 110
5 10-5	2	5	6:15 P.M.	64	9:15 P.M.	68	3	165	135	125	200 200
5 10-5	2	4	10:00 P.M.	64	1:30 A.M.	70	3½	145	110	85	120 125
5 10-5	2	4	2:15 A.M.	65	4:15 A.M.	70	2	130	90	80	145 145
5 10-5	2	5	5:45 A.M.	67	7:45 A.M.	72	2	145	95	60	125 125
10 10-7	1	3	10:00 A.M.	66	12:00 N	72	2	125	90	55	120 120
10 10-7	1	3	2:00 P.M.	68	4:00 P.M.	72	2	100	55	40	120 125
	1	3	4:45 P.M.	68	6:15 P.M.	69	1½	80	75	60	100 100
	1	3	12:15 A.M.	65	1:45 A.M.	70	1½	130	95	80	140 100
	1	3	5:00 A.M.	65	7:30 A.M.	72	2½	130	80	45	90 140

Fig. 57. Sample of a Record Kept by One of the Electricians.

amount to 150 amperes. If the *generator voltage* is kept constant at this value it will be found that the battery current will fall off as the batteries take their charge.

Undoubtedly the constant current principle of charging is more accurate from a battery point of view, but because of the fact that much of the charging is done at night when part of the generator current goes to the lamps and part to the battery, and it is then difficult to tell how much current the batteries are getting, a combination of the voltage and current methods of charging is best for this particular service.

Where any battery is very low it is charged by itself (if car is received at night put up 2-wire connector at front end and short circuiting plug at the rear end) and the charging current kept constant at 30 amperes until the voltage rises to about 80 volts at the generator. When all batteries are in fairly good condition the generator voltage is then raised to 85 volts in day-time, or 90 volts with full lamp load on, and kept at that voltage, allowing the charging current to taper off as the batteries become fully charged.

Specific gravity readings are taken of all batteries at the end of each run so any instances of undercharging are discovered.

In order to keep a check on the charging of storage batteries in this service the management have periodically placed ampere hour meters in each battery circuit of the train which record the total ampere hour charge and the total ampere hour discharge. A record of one battery covering 39 days shows an average discharge of 84 ampere hours per day and an average charge of 113 ampere hours per day. This represents a 19 per cent overcharge, which is about as near the correct value as can be given. Another record of a battery covering 38 days shows a discharge of 46 ampere hours per day and a charge of 87.6 ampere hours per day, representing an overcharge of 90 per cent. This is a rather excessive percentage, but when it is considered that the over-

charge is but 41 ampere hours per day, about ⅛ of the battery capacity, it might not be considered excessive. Still another record covering 50 days shows a discharge of 73 ampere hours and a charge of 70 ampere hours per day which indicates a slight undercharging which might eventually make trouble in causing the plates to sulphate. While these records do not indicate any serious trouble, it is very important to keep a close tab on battery current and voltage during charge so that you may know when a charge, somewhere near the proper amount, has been given the battery.

The Lamp Regulator.

For the benefit of some of the headend electricians who have not studied the lessons on axle systems very carefully we will give a brief description of the fundamental principles of the lamp regulator.

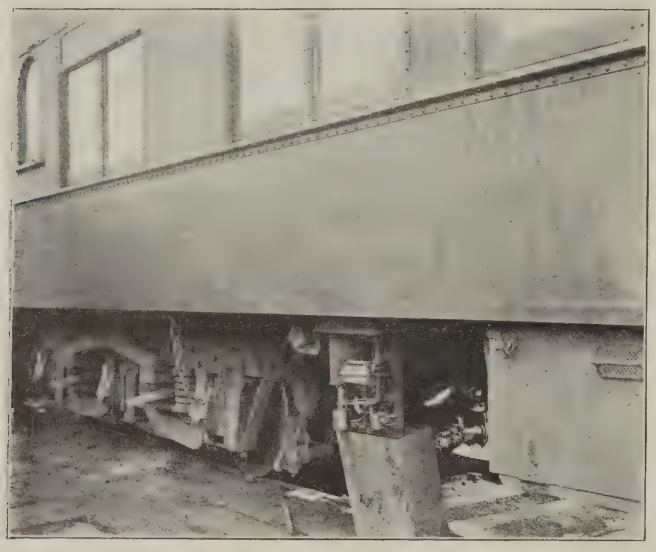


Fig. 58. Lamp Regulator with Case Removed.

When you place any resistance in series with a lamp circuit it will reduce the voltage across the lamps by a certain amount, depending upon the amount of resistance inserted. In these lamp regulators the resistance, which consists of a pile of carbon blocks, placed in the lamp circuit, is automatically adjusted to such a value as will reduce the line voltage, which may be anything from 64 to 78 volts, down to the normal voltage of the lamps (63 volts).

Everything that conducts electricity whether it be copper wire, iron wire, water, acid in batteries, lead or iron plates, or pieces of carbon, offers a certain amount of resistance to the flow of the electric current through it. With some things this resistance is much higher than with others. A piece of iron wire or a block of carbon offers a very high resistance to the flow of current, while with copper wire the resistance is very low, but even with a heavy copper train line, the resistance is enough to cause a drop of 4 or 5 volts over the total train line with full load current flowing.

But to get back to our lamp regulator: if a pile of 20 or 30 carbon discs is connected into a lamp circuit and arranged so that the pressure on the discs can be varied, it will be found that the voltage drop due to the lamp current flowing through the pile of carbon discs will be considerably less when they are squeezed tightly together than it is when the pressure is reduced. The greater the pressure, the less the resistance, and with less pressure the resistance of the pile increases.

Now the lamp regulator is simply an automatic device which varies the pressure on such a pile of carbon blocks through which the lamp current flows. This pressure is caused by the magnetic pull of a solenoid on an iron plunger in the center of it acting through a system of levers, and the amount of the magnetic pull of the solenoid depends upon the voltage across the lamps; the higher the lamp voltage the greater will be the current through the solenoid and the greater the pull; (See Lesson I, Feb. 1912), the less the lamp voltage the less will be the magnetic pull. This solenoid then adjusts the pressure on the carbon blocks so as to make the voltage drop of the lamp current flowing through it of such a value as will reduce the train line voltage down to 63 volts, which is normal lamp voltage. With a train line voltage of 70 volts, there will be 7 volts drop through the carbon pile; if the train line voltage raises to 78 volts the regulator will automatically loosen the pressure on the carbon blocks until the voltage drop through it amounts to 15 volts and cuts the train line voltage of 78 volts down to 63 volts normal lamp voltage, etc.

Almost any of the various types of lamp regulators now employed in axle service can be used in maintaining constant lamp voltage in each car circuit. These are usually mounted under the car as shown in the accompanying illustration, one regulator on each car in the train. Where there is a secondary relay or "multiplier" used in connection with the lamp regulator, it is usually placed in the switch board locker inside the car.

The generator voltage should not be run above 85 volts at night for it must be remembered that the difference between normal lamp voltage of 63 volts and train line voltage of 78 volts (85 volts at the generator less 7 volts drop in train line) must be absorbed in the lamp

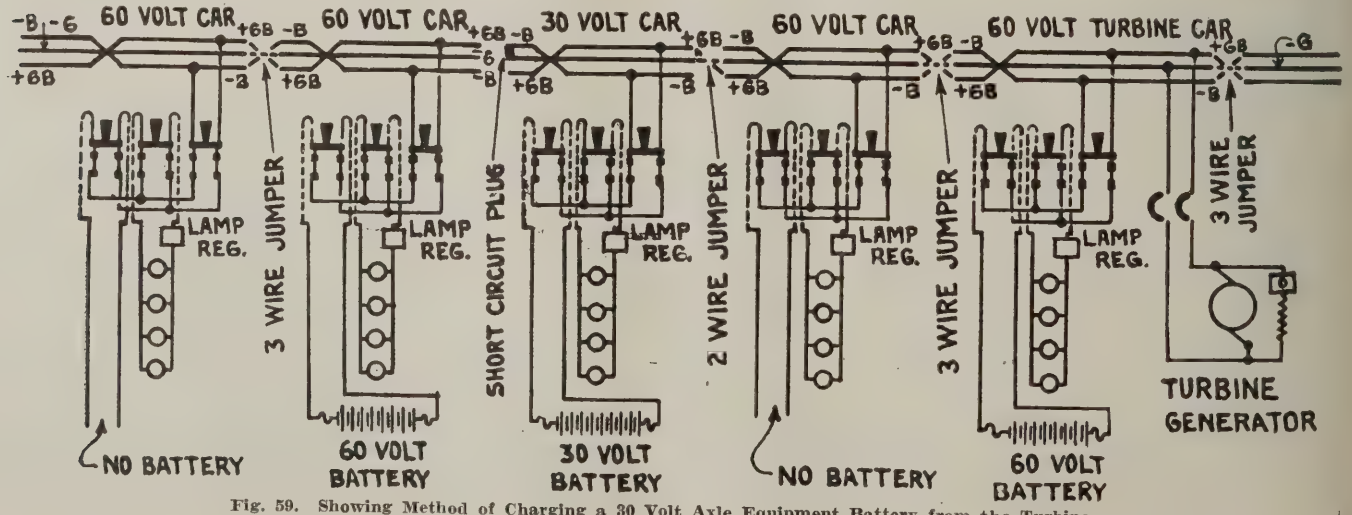


Fig. 59. Showing Method of Charging a 30 Volt Axle Equipment Battery from the Turbine.

regulator. When all the lamps are turned on the heating effect of this voltage drop of 15 volts through the regulator with a heavy current flowing may be very great, and if the generator voltage is allowed to run as high as 90 or 92 volts, this may bring the train line voltage up as high as 85 volts, which would require that 22 volts be absorbed in the lamp regulator in order to bring the voltage down to 63 volts normal. Under these conditions, the generator at 92 volts would cause 50 per cent. more heat to be generated in the lamp regulator than with the generator voltage at 85 volts. This might easily overheat the lamp regulator and cause serious arcing and burning away of the carbons.

A diner with a 30 volt axle system is often picked up on this run and occasionally the generator is in trouble, so it becomes necessary for the electrician to charge it from the turbine set in the dynamo car. Of course, in doing this the voltage of the generator must be lowered down to 40 or 50 volts. This is way down below the normal voltage of the head-end system, so the 50 volt circuits for lamps and batteries of the head-end system must be entirely separate from the 40 or 50 volt circuit of head-end generator and axle battery.

Some of the 60 volt cars are equipped with battery and some are not, so the three wire connectors must be left up between all 60 volt cars. A two wire connector, however, is placed between the 30 volt diner and the car ahead, as shown in Fig. 59, and the connector at the rear of the diner is pulled and a short circuiting plug which connects the negative generator to negative battery on the diner train line is inserted.

This gives us then two entirely separate circuits on the three wire train line: one at about 63 volts and the other at 40 or 50 volts. They have one wire in common, the generator and battery positive. The 60 volt battery ahead of the diner lights the 60 volt lamps both in its own car and the next car back which has no battery. The 30 volt lamps and battery in the diner are taken care of by the head-end generator, and the lamps in all cars to the rear of the diner, whether that car has a battery on it or not, are lighted from the 60 volt train line which is supplied by the batteries on the other cars to the rear of the diner.

PRACTICAL STUNTS.

Send in your ideas, we pay for them.

Flickering Lights.

If the lights on a headend train begin to flutter and go up and down, you may be pretty sure it is because of a loose train connector. This is dead easy to find, for if you throw in the loop switch in the dynamo car the flickering will immediately stop in all cars ahead of the loose connector, but the lights will continue to flicker in all cars to the rear. By walking back through the train the connector between the car with lights O. K. and the car with flickering lights can be tightened, and this will in almost every case clear up the trouble.—R. Daniels.

A Reversed Generator.

It is a pretty important thing to have your voltage right on a headend set before closing the switch. While trains are lying in the Chicago Terminal, they are lighted from a 60 volt station line. Shortly before departing however, the headend turbine set is cut in when the voltage of the turbine becomes equal to that of the station line.

The other day one of our men in starting his turbine set threw in the main switch when the generator voltage had reached only about 30 volts. Of course, the 60 volt train line slammed a heavy current through the generator armature which was then only developing 30 volts. This motored the generator causing a very heavy reversed current to flow through the compound field winding. The generator circuit breakers went out, which would indicate that this reversed current reached a value of 200 amperes.

The magnetism of this reversed current was so strong that it entirely reversed the fields of the generator, so that after the breakers went out the generator was building up in the wrong direction. This had the train electrician pretty badly mixed for a while until he connected his generator field across the battery and put current through it in the right direction. After this the generator built up O. K.—J. A. A.

Axle Lighting

FROST EVERETT REGULATOR.

The regulator taken up in this month's lesson is that devised by Messrs. F. R. Frost, Elec. Engr., and S. W. Everett, Asst. Elec. Engr., of the Santa Fe. It is radically different from any of the other types of generator regulators now in use. Any of the various types of generator, regulator lamp and automatic switch can be employed, the machine regulator alone having distinctive features.

A resistance of a value high enough to hold the generator voltage down to normal value even at the highest speeds of 80 or 90 miles per hour, is placed permanently in series with the generator fields. This resistance is divided into two separate parts, one about one-third of the total and the other about two-thirds. A pair of carbons making contact with each other short circuits each part of the resistance, and when the dynamo is building up the short circuiting carbons are held tightly together and allow full generator field current to flow uninterrupted.

Referring to the diagram in Fig. 61, "A" is a shunt wound dynamo, "B & C" are solenoids connected in series with the dynamo, battery and lamps. "D & E"

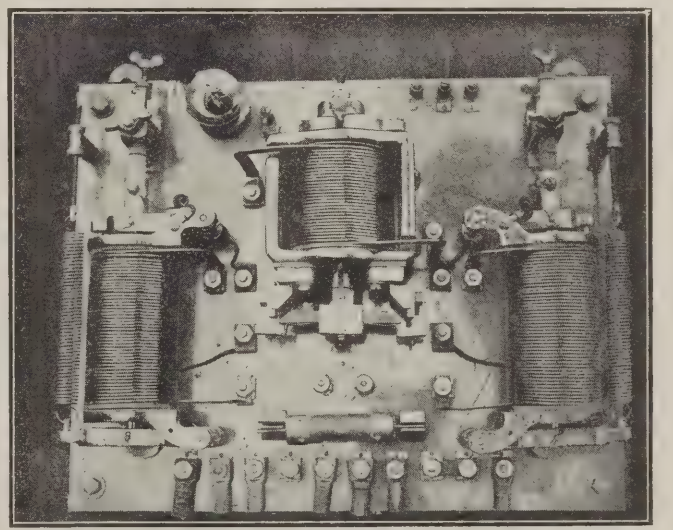


Fig. 60. The Frost-Everett Regulator; U. S. Lt. & Htg. Co.'s Type F-7 Panel.

are movable iron cores of the solenoids B. & C., and are held up by adjustable springs not shown. F. & G. are resistance units placed in series with the shunt field of the dynamo. H. & I. are pieces of carbon fastened to the movable cores D. & E. and connected by flexible leads to the lower end of resistance units F. & G.; they are normally pressed against the carbons J. & H. by the adjustable springs. J. & K. are pieces of carbon rigidly fastened to the panel board, connected together and also to the top of the resistance units F. & G.

When the generator first starts to build up, these carbon contacts are held tightly together by the upward

pull of the vertical springs on each side of the board as shown in Fig. 60. These springs are adjustable and one coil is set to operate at about 5 amperes higher than the other. That is, if the run is such that it requires about 28 amperes average setting of the machine, the right hand coil will be set at 30 amperes and the left hand coil at 25, making an average of about 28.

Upon closing the automatic switch, and with a slight increase in train speed, the generator current will rise to 25 amperers, the setting of the left hand coil. The magnetic pull downward of the coil on the iron plunger will then be just sufficient to balance the upward pull of the spring, and an increase in current will pull the plunger down and cause it to vibrate slightly. One carbon is mounted on top of the iron plunger as shown, and the other fastened permanently to the board, so pulling down the plunger opens the contact between the carbons.

When the dynamo goes above the predetermined current of say, 25 amperes, the solenoid "B" pulls down core "D" breaking the contact between carbons J. and H. putting resistance "F" in field circuit. This causes the output of generator to drop below 25 amperes and weakening the magnetic pull of solenois "B," allows the carbons J. and H. to come together. short circuiting the resistance F, and again boosting the field current. This cycle of operation is repeated very rapidly when regulation is necessary.

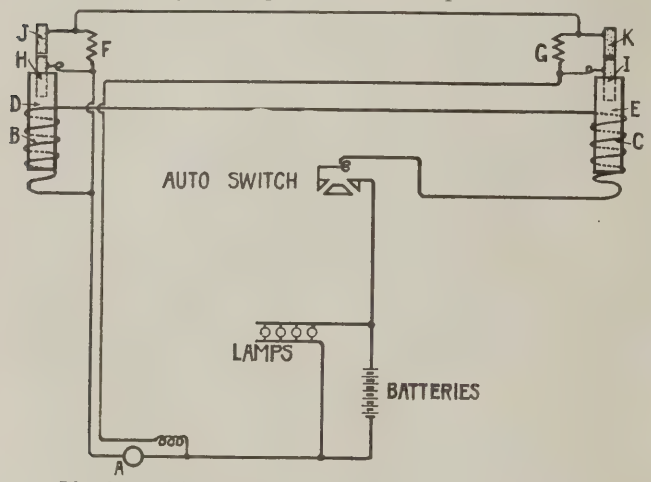


Fig. 61. Wiring Diagram of the Frost-Everett Regulator.

When the contact between carbons J. and H. is momentarily broken the field current does not drop to the minimum value that would be caused by resistance F. alone, on account of the very short time that this resistance is in circuit, neither, on the other hand, will the field current rise to the maximum value that it would with the resistance F permanently short circuited by the carbons.

This is due to the magnetic inductance of the generator field, which might be more properly called magnetic "inertia," for when the generator field circuit is first closed it takes some time to build up the current to full value, just as it takes some time for a heavy weight, such as a train, to get up to full speed. In some generator fields this may take as long as a second or two. In a similar manner, after the field current is once well established, it is hard to stop it, just as it is hard to stop a heavy train going at high speed, so that even though the total resistance of the field circuit is caused to change very rapidly from low value to high value. the enertia effect of the generator fields, keeping the field current at an *average* value, and the vibration between the two short circuiting carbons is such that the generator field current will be maintained at the correct value to keep the generator output at the setting of that coil.

This vibrating action will continue until the train speed rises to such a point that the total value of resistance F, is required in the field circuit to keep the current at the predetermined amount. At this time the solenoid core "D" will cease vibrating and the carbons J. and H. remain permanently separated. As the train speed further increases, the current output of the generator will rise to the setting of the right hand coil "C", which is about 5 ampers above that of the first coil "B". As the train speed further increases to about 25 miles per hour and the output tends to rise above this higher setting, however, the carbons K. and I. will begin to vibrate, rapidly cutting the resistance G. in and out of the generator field circuit. This action is identical with that of the coil B. and the generator current will be maintained at the setting of the higher coil even though the train speed rises to a high value.

On decrease in speed below about 25 miles per hour, the carbons K. and I. will have ceased vibrating and permanently short circuit the resistance G. With a further decrease in train speed the generator output will fall from say 30 amperes to 25 amperes, the setting of the left hand coil, and as the train speed further decreases and the generator current tends to fall below this value, the carbon H. will begin to vibrate rapidly, making contact with the upper carbon J., short circuiting the resistance F. for short periods of time. This causes an increase in the generator field current to such a value as will maintain the generator output at the setting of this coil.

This system of regulation is successfully used on over 400 cars on the Santa Fe and 100 cars on the Western Pacific, as well as a large number in South America.

About the only maintenance required is to occasionally smooth up the ends of the carbons with a piece of emery cloth where they make contact with each other. This regulator is manufactured by the U. S. Lt. & Htg. Co., and is known as their F. 7 Panel.

Question Box

Question.—Will you kindly tell me which of the following quotations are correct. I read in a battery instruction book (no temperature mentioned): "Resistance of electrolyte is at a minimum at about 1.225 specific gravity, rising if the gravity be either increased or decreased." Then again I read in the book on Practical Lessons in Electricity, page 23, "The advantage of a strong solution is its lower resistance; but it is likely to produce a very objectionable effect of 'sulphation.'" I presume by a "strong solution" they mean 1.260 or 1.300.—Harvey Davies.

Answer.—At a specific gravity of 1.225, the resistance of sulphuric acid electrolyte is a minimum. If the gravity be either increased, by adding more acid or decreased by adding more water, it will cause a slight increase in the resistance of the electrolyte. Obviously, it is of advantage to use an electrolyte of as low resistance as possible, and in car lighting work 1.225 or 1.230 is about standard for gravity with the battery fully charged. On discharge, however, the gravity is going to fall off to 1.170 and the resistance will accordingly increase.

When considering only the resistance of electrolyte the proper gravity on full charge would be 1.250, and at discharge 1.200, giving an average of about 1.225. This would give a minimum average resistance of the electrolyte.

Strong acid of 1.250, however, causes "sulphation" a great deal more rapidly than normal acid of 1.225. So, although the 1.250 acid might give a little higher battery efficiency, in that the internal resistance of the battery would be less, the plates would be very much more liable to sulphate and cause trouble.

(*Car Lighting Lesson to be continued next month.*)

Personal

E. M. CUTTING JOINS EDISON FORCES.

Mr. E. M. Cutting, Engr. Tr. Ltg. Htg. & Vent. of the So. Pac. Co., has just accepted the appointment as representative of the Edison Storage Battery Company

E. M. Cutting.

on the Pacific Coast with headquarters at San Francisco, No. 818 Mission street.

Mr. Cutting entered into railroad work at the age of 16, in 1888, and has been engaged in railway electrical work of one nature or another ever since. In 1898 he was appointed supervisor of signals, succeeding Mr. Slater, who was promoted to Signal Engineer for the Southern Pacific Company. In 1902, in addition to his duties in the Signal Department, Mr. Cutting was given charge of all matters of electric train lighting, which department was at that time growing very rapidly. In 1909 he was relieved of his duties in the signal department and since that time has devoted his attention exclusively to train lighting, heating and ventilation.

Mr. Cutting was elected President of the Association of Railway Electrical Engineers in 1909, and has always been a most enthusiastic worker, and has done much effective work even though handicaped by a great distance from the majority of the men interested in this line.

While supervisor of signals, Mr. Cutting inaugurated a signal instruction course among the signal men under his supervision which was very popular, and proved to be one of great economic value both to the road in improving the efficiency of the men and bettering their signal service, and to the men themselves, making it possible for them to subsequently fill prominent positions in the signal departments of many of the Western roads.

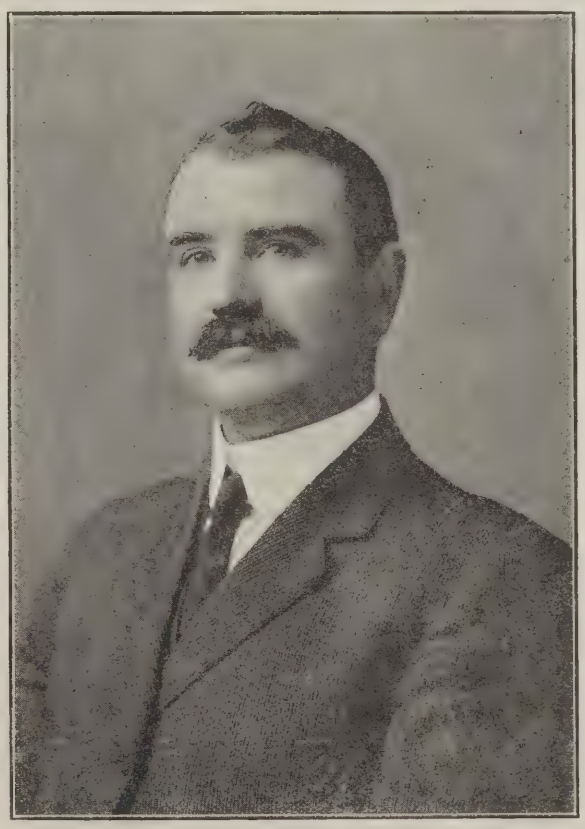
Mr. Cutting has always been an ardent believer in the education of the men under his supervision and has tried to give his men every opportunity possible to improve themselves.

We believe that we voice the sentiment of all the A. R. E. E. men in the electrical departments of the various railroads in extending to Mr. Cutting our New Year wish for the greatest measure of success in his new endeavors.

J. J. HACK APPOINTED ENGR. TRAIN LTG. HTG. & VENT., SO. PAC. CO.

Mr. J. J. Hack, formerly supervisor of electric lighting of the Southern Pacific Co., has just been appointed Engineer, Train Lighting, Heating and Ventilation to succeed Mr. E. M. Cutting, resigned.

Mr. Hack is a pioneer in car lighting work, having



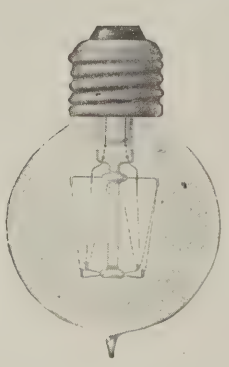
J. J. Hack.

been in the employ of the Southern Pacific Company as Electrician and on other various rungs of the ladder of his success, since 1889. At that time the Southern Pacific Company had just installed a head-end train lighting system on the Golden State Limited, but shortly after this he began to receive axle lighted cars equipped with the old Moskowitz machines, and in the course of the next three or four years the electrical department developed rapidly.

Mr. Hack has then been engaged in train lighting work for over 23 years, and for 12 years has been as-

The Five Essentials

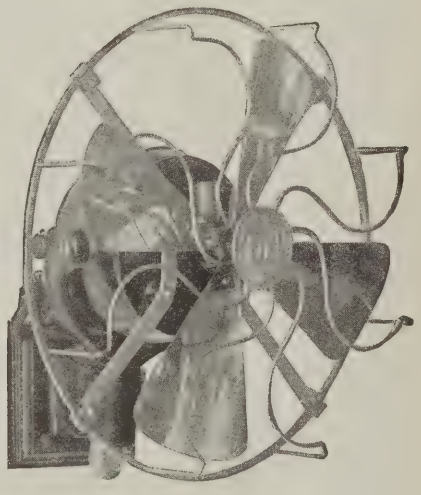
Columbia Mazda Lamps



Drawn Wire Filaments

The mechanical strength of the new Columbia Mazda Lamp has added greatly to its life. In addition it has increased electrical efficiency. We carry an immense stock of low voltage lamps for train lighting service as well as the standard sizes and styles of lamps for ordinary voltages.

The Standard for Train Lighting



Diehl Car Fans
FOR
Railway Car Service

They are the best. When the manufacturers could no longer improve the motor they improved the base. These bases are of artistic design and may be permanently mounted in the cars. The Fan is easily and quickly removed without disturbing its base. No marring of woodwork—no loss of time.

Ask for Additional Information

Demand on all your orders QUALITY
THE HOUSE OF SERVICE, carrying the
or West. Prompt shipments are our
ing catalogue, it will go to you for the

Central Elect

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to First Class Service

OKONITE

TRADE MARK.

Standard of All Rubber Insulations

Okonite insulation with its toughness, elasticity and high electrical resistance is always placed concentrically around the conductor. The result is a product absolutely dependable.

Wire installed in railway cars should be the best. *Okonite* is made in one grade only—THE BEST.

D. & W. Fuses

The Standard by Which All Enclosed Fuses Are Judged

Construction of link used in fuse in operating under severe conditions.

D. & W. Fuses are scientifically designed with maximum service and a resultant minimum volume of metal for a given current value. This enables fuses of reasonable dimensions to meet abnormal conditions of overload. The fibre tubes are exceptionally strong. They are manufactured with steel reinforcing rings when necessary.

Specify D. & W. Fuses and secure the protection you need.

and SERVICE—then write us. We are largest stock of electrical supplies East specialty. If you have *not* our big instruct- asking. Write for it on your letterhead.

rir Company

of Service CHICAGO, ILL.

sistant to Mr. E. M. Cutting. He was one of the original ten men who met at Ogden several years ago and formed the neucleus which ultimately developed into the Association of Railway Electrical Engineers. In a letter to the writer, Mr. Hack states that he considers this one of the best things that he ever had the pleasure of helping to accomplish.

Mr. Hack attended the convention of the Association a year ago, so many of us are already well acquainted with him, and those of us who are can assure the rest of us that we are going to find a good live wire and an active worker for the Association in Mr. Hack.

CRAVENS ELEC. CO. BECOMES AGENTS FOR ELECTRIC WELDING OUTFITS.

The Cravens Electric Co. of Chicago has recently further increased its scope by securing the exclusive sales agency for the C. & C. Electric & Mfg. Co. covering a large portion of the middle west. This line includes not only the well known C. & C. motors and generators but also the electric welding outfits which have been adopted by some of the largest concerns. This is the make of apparatus that was recently purchased by the Central Railroad of N. J. after exhaustive and rather interesting tests.

The Cravens Electric Co. has increased its facilities for manufacturing distribution panels, switchboards, disconnecting switches and other power station equipment, of which it makes a specialty. They will also continue as agents for the Eastern Electric Lamp Co.

They announce that beginning with the first of the coming year Mr. W. P. Naser will be affiliated with that company as Sales Manager.

Mr. W. P. Naser, the new Sales Manager of the Company, has for the past four years been very successful as the manager for the Electrical departments of both the New Orleans and the Texas branches of the H. W. Johns-Manville Co. He has had a thorough technical and commercial training in both the British and American Works of the Westinghouse Co.

OLIVER ELEC. & MFG. CO. INCREASES PLANT.

The Oliver Electric & Manufacturing Co. of St. Louis, advise that the rapid growth in their business has been such that they have found it necessary to practically double their floor space, and have installed five additional machine tools to better take care of their business. They have also increased their capital stock from $25,000.00 to $50,000.00, this increase being taken care of by the present stockholders.

THE ILLUMINATION OF METAL WORKING PLANTS.

This is the title of a non-technical bulletin just issued by the National Electric Lamp Association. The bulletin shows many interesting photographs of effective installations and gives some interesting comparisons of cost of operation of flaming arc lamps and tungsten units.

ELECTRICAL OPERATION OF RAILWAY SHOPS.

This is the title of an excellent bulletin on this subject just issued by the General Electric Co. It draws interesting comparisons between independent drive and group drive, and alternating current and direct current installations. It also gives a detailed description of certain typical shops, numerous examples and certain types of drive. The book is well illustrated and of considerable value to any man in charge of railway shop motor equipment.

THE "BEEHIVE" TRIO.

To complete the so-called "Bee Hive" trio, a series of widely distributing reflectors, the National X-Ray Reflector Company of Chicago has produced a new type that you see illustrated below. The original and well-known "Bee Hive" reflector, which has been on the market for a couple of years, was designed expressly for the illumination of the Patten Gymnasium of the Northwestern University. The manufacturers have since found an extensive application for this reflector in large high rooms, in factories, shops, armories, gymnasiums, press rooms, etc. The large "Bee Hive" was designed for 100, 150 and 250 watt lamps.

One of the Bee Hive Reflectors.

The No. 565 gives the best results when used with 60 and 100 watt lamps. This new reflector is made of glass in one piece and it is comparatively small, being only 7½ inches high and 7¼ inches in diameter.

The third member of the "Bee Hive" trio is a small reflector, No. 555 for 25 and 40 watt lamps. The peculiar designs of the "Bee Hives" make them very effective when shielding tungsten lamps from view.

The No. 565 reflector may be used whenever a wide spread of light is desired from ceilings of average heights.

NATIONAL MAZDA LIGHT FOR RAILWAY SERVICE.

This is the title of a new pamphlet just issued by the National Electric Lamp Association. The pamphlet takes up in considerable detail the value of lighting stations, offices, repair shops, yards, freight houses and platforms.

It demonstrates that the possibilities of lighting in these various points of railroad system should not be overlooked by the different railroads, in fact, shows that it is really a good investment to provide good light.

The book is rather elaborate, and contains some excellent illustrations of car lighting, station lighting, platform, shop and yard lighting.

It will gladly be sent on request to the National Electric Lamp Association, Cleveland.

TECHNICAL DATA BULLETIN.

The Delta Star Electric Co., Chicago, are distributing a new 32 page data bulletin devoted to high tension distribution. The data given on 33,000 volt line construction, method of lighting protection, etc., will be of interest to operators of high tension systems.

POSITION WANTED.

A man having had 8 years experience as electrician at the St. Louis yards of the Vandalia (Pa. Term.), wishes to get back into the car lighting game. He is a man of more than ordinary ability and we hope this notice, unsolicited on his part, will prove effective. Address A. H. N. care Railway Electrical Engineer, 106 N. La Salle St., Chicago, Ill.

RAILWAY ELECTRICAL ENGINEER

Official Journal
of the Association of Railway Electrical Engineers.
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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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The Postal Car Specification.

Of the specification for the construction of steel full postal cars recently prepared by the Postal Department and published in another part of this issue practically one-half of the entire specification is given over to a consideration of the illumination features. This is an impressive recognition of the fact that the illumination of cars is a subject which should be given a most careful consideration by railway men. This specification provides both for initial illumination values and for service illumination values in various parts of the car. The initial illumination values at first glance might appear comparatively high, but with the ordinary depreciation of 20 per cent in the candle power of the lamp at the end of its life and a normal depreciation in reflecting efficiency equal to approximately the same amount, the initial values become equal to the service illumination values, requiring a minimum of 2.8 ft. candle horizontal illumination in the bag rack and letter case section of the car, and this is not at all unreasonable.

As to what layout of lighting units in the various sizes of lamps will be required to meet this specification we are very pleased to submit as a supplement to the government specification a few layouts prepared by Mr. A. J. Sweet, who has made a most careful investigation of this subject, and who is especially well qualified to prepare such a series of layouts.

It will be noted from these diagrams that where 25 watt lamps are installed throughout, the current consumption is somewhat lower than when 50 watt lamps are used, and similarly 15 watt lamps meet the specification with a somewhat lower current consumption than the 25 watt lamps, although the difference between the 15 and 25 watt lamps is not near so marked as between the 25 and 50 watt lamps. This is because of the fact that the small size units can be spaced more economically to give the minimum value of illumination required than the larger units can.

The fact that this specification differentiates between the various types of reflectors shows that it is far from being an arbitrarily established requirement by postal authorities. As a matter of fact, this specification is, in part at least, based upon the results of a most complete investigation of postal car lighting, which was conducted by one of the Eastern roads last summer.

The importance of the choice of reflector for this service cannot be too strongly stated. It is a well established fact that the difference between the illumination produced on the reading plane where a high grade reflector is used and where a low grade reflector is used may easily be as great as two to one. The lamp position in the reflector is also an important factor in obtaining maximum efficiency.

The fact that where indirect lighting is employed the minimum values of the specification may be reduced from 25 to 40 per cent may result in a rather extensive use of this type of illumination for postal car lighting. With the old style clear story type of roof construction, indirect lighting is placed at a great disadvantage because of the comparatively small reflecting surface of the upper deck, and also because of the fact that the quarter deck and window ventilators intercept so much of the light that the efficiency of the system is greatly reduced; but in the turtle back roof type cars a large and continuous reflecting surface is provided and indirect lighting will here undoubtedly find a much wider and more successful application.

Indirect Lighting.

Although indirect lighting is still in the experimental stage as applied to railway passenger cars, it is receiving a wide application in illumination of waiting rooms, offices, drafting rooms, residences, etc. In fact, it invariably meets with great favor and success wherever the consideration of artistic treatment or relief from eye strain are given more weight than any consideration of lumens per dollar. Although there is some loss by the double reflection, first from the reflector unit, and second from the white ceiling above, this decrease in illuminating efficiency is practically compensated for by the increase in eye efficiency or ability to see, where the indirect system of lighting is installed. It is well known that whenever a bright source of light comes into the field of vision, the pupil of the eye contracts and thereby cuts down the amount of light admitted to the retina. This may cause acute pain and always results in a

marked decrease in one's ability to see temporarily; if such conditions are allowed to continue, however, they often cause serious eye trouble.

Even when the light itself does not come directly in the field of vision, as when the lamp is properly concealed within the reflector or placed high above the range of vision, the specular reflection or glare from the surfaces of paper or other objects in view may reduce the eye efficiency in a manner very similar to that of the bare lamp in the field of vision. With indirect lighting where the whole ceiling is more or less brilliantly illuminated, the light coming to the observer is very diffuse and comes from a multitude of different directions so that there is no glare either directly from the lamp or by specular reflection to cause a reduction in eye efficiency.

Although it is impossible to vary the illumination on the working plane by raising or lowering the indirect fixture as it is with any direct lighting unit, the relation of mounting height to the height of ceiling and the distribution curve of the reflector used are very important considerations in the design of indirect lighting installations. When the ceiling of the room is high enough so that the lighting unit may be mounted 8 or 10 ft. below the ceiling and where several units are installed, the distribution curve of the reflector is not of so much importance, but in rooms with low ceilings both the distribution curve of the reflector and the diameter of the indirect lighting fixture become of special importance.

Since the distribution curve of a beam of light striking a diffusing surface such as a white ceiling at any angle is a circle tangent to the ceiling, the direction of the main light flux from any given reflecting area will be directly downward. Obviously, then, the distribution curve of the reflector should be such as to distribute the major part of the reflected light in such a direction as will strike the ceiling at a point several feet away from the outer edge of the indirect unit. A large part of the light sent vertically upward by the reflector is reflected back from ceiling in a downward direction and is intercepted by the lighting unit itself. So it is at once evident that the amount of light intercepted by the unit should be reduced as much as possible by making the entire unit of a small diameter and by distributing the light over a comparatively wide circle instead of concentrating it in a small area directly over the unit. Too extensive a reflector, however, must not be employed for this will allow too much of the light to be directed on the upper wall area instead of reflecting it to the useful plane below.

Effect of Clean Lamps on Lighting Efficiency.

The high candlepower tungsten lamp forms the basis for an extremely efficient and economical system of industrial lighting. However, to get even 50 per cent. of this efficiency, the lamp must be supplemented by a reflector so designed that it will deflect and re-direct the rays of light, delivering them between useful angles below the horizontal. Even this combination is of little value unless the lamp and reflector are kept clean, and the cost of this cleaning will be great or small according to methods adopted.

The money invested in reflectors for mill lamps amounts to many hundreds of thousands of dollars. The moment these reflectors become coated over with dirt they cease to be reflectors, and that enormous investment becomes unproductive.

To get only 50 per cent. or 75 per cent. of the illumination produced by the lighting equipment is just as real a loss as to get but 50 per cent. or 75 per cent. of the pig iron, coal, wire, or any other commodity which is purchased and paid for, because industrial illumination affects the value of every employee connected with the plant.

LECTURE ON TUNGSTEN.

At a recent meeting of the New York Electrical Society, Dr. Charles Baskerville delivered an interesting lecture on "Tungsten". The author reviewed the history of the metal from the time of its discovery by Scheele in 1781, when it was called "Tungstein," and gave many important historical dates and names of the scientists associated with the development of pure metalic tungsten in its present form.

Tungsten is found and mined as tungstates of the various metals, the principal one being the iron salt, known as "wolframite," represented by the formula $FeWO^4$.

Tungsten may be prepared from wolfram by heating the powdered ore with sodium carbonate, extracting the sodium carbonate with water, filtering and adding an acid to precipitate tungstic acid. H^2WO^4. This is washed and dried and the oxide thus obtained is then reduced to the metal by heating with carbon to a high temperature. Tungsten is also obtained by heating the oxide with carbon in an electric furnace, in which case the product is porous and can be welded like iron.

Reference was made to the various uses of tungsten and its alloys. Particular attention was given to the tungsten filament as being the application of most interest to the electrical engineers. The speaker told of the difficulties encountered in removing from the metal impurities such as sulphur, arsenic, antimony and phosphorous, which was very essential in order to obtain a sufficiently strong and uniform filament. Besides this, the carbon which is used in producing the tungsten must be removed, which caused considerable difficulty. The honor of the development of tungsten, the speaker said, has wrongly been claimed by and given to Austria, when, in fact, it belongs to America. Credit should be given particularly to Dr. W. R. Whitney, of the General Electric Company, for bringing the tungsten filament to its present state.

DATES IN THE HISTORY OF TUNGSTEN.

1781.	Tungstein discovered	Scheele
1783.	Wolfram containing tungsten	Dr. Elhuyer
1815.	Alloy with iron	Hassenfratz
1826.	Atomic weight	Berzelius
1836.	Yellow to blue oxide	Malaguti
1868.	Five per cent. tungsten steel rails.	
1882.	Tungsten shot	Mieg and Bishoff
1887.	First filament	Bottome
1903.	Filament	Just and Hanaman
1905.	Filament	Kuzel
1905.	Filament	Auer von Welsbach
1907.	Filament	Siemens & Halske
1908.	Filament	Westinghouse
1910.	Filament	General Electric Company

ELECTRIFICATION PROGRESSING IN ENGLAND.

Another steam railroad terminating in London has decided to adopt electrification for its suburban traffic. An announcement of this decision has been made by the London & Southwestern Railway.

The action of the London, Brighton & South Coast Railway in electrifying its suburban lines has been remarkably successful in winning back traffic which had previously been lost to the electric railways in the same territory.

New C. B. & Q. Ry. Office Building

The new 17-story office building at Chicago of the C. B. & Q. R. R., which has just been completed, is one of the biggest private railway office buildings in the country and has many features which are of interest.

The building is of an almost triangular shape, fronting 151 feet on Jackson boulevard and 175 feet on Clinton street with the elevated railroad abutting the hypotenuse of the triangle. So the building has an unobstructed view on all sides and the lighting within during the day time is excellent. For artificial illumination the building is completely equipped with indirect units of the "Alexalite" type, using 100, 150 and 250 watt tungsten lamps as the occasion requires.

We show herewith a view of two of the more important rooms, the telegraph office and the drafting room. In the telegraph office there are 19 250 watt units installed. The room is approximately 42x52 feet, an area of 2184 sq. ft., this makes a current consumption of 2.2 watts per sq. ft. Without doubt the size of the

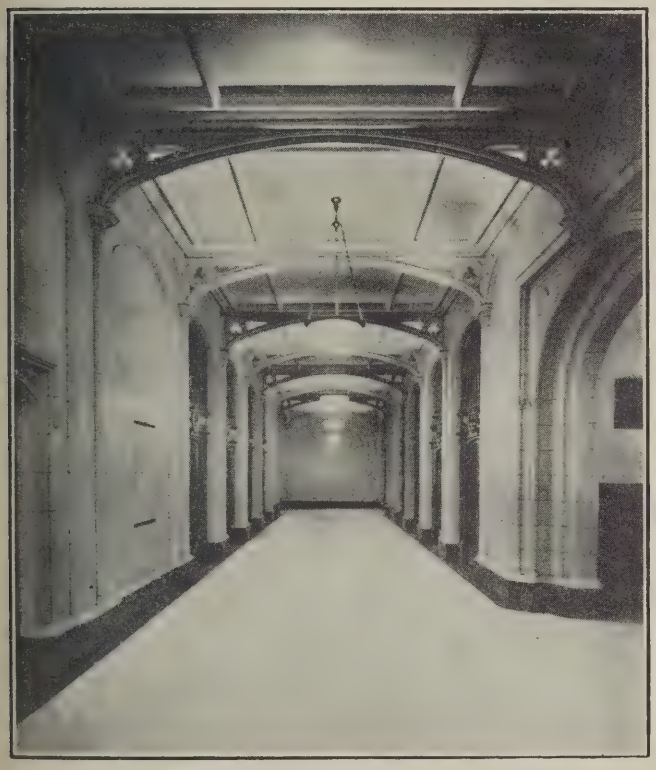


Fig. 1. Main Corridor and Entrance to Elevators.

lamps installed will be reduced after the illumination tests have been made, for the present installation provides really more than sufficient illumination. At the present time no illumination tests of this big installation have been made, but these will be available in a short time and results published in these columns.

The general effect of the indirect lighting in this building is most pleasing, for there are no bare lamps whatsoever in the field of vision. Obviously all drop lights and desk portables have been relegated to the discard heap. The illumination in all of the rooms of the building is very uniform and well distributed.

This particular lighting unit, known by the trade name "Alexalite," is a white enameled steel reflector bowl of decorative lines suspended below the lamp by means of three chains. Any one of these chains may be unhooked and the bowl reflector tipped to a vertical position for cleaning. This permits that an accumulation of dirt may easily be crushed out and the reflector wiped clean.

The main corridor of the building on the first floor is illuminated by large diffusing bowls beautifully etched in a decorative color design, as shown in the accompanying illustration.

Fig. 2. The New C. B. & Ry. Office Building.

A complete power plant of the most approved engineering practice is installed in the sub-basement of the building. Two 300-k. w. and one 100-k. w. direct current Corliss engine generator units are installed. These engines run non-condensing and have 20x36 in. cylinders and 12x36 in. cylinders respectively. The 300-k. w. unit runs at 125 r. p. m. They are equipped with the new long range cut-off and a special type of governor. An emergency stop is provided to prevent the engine from running away, in which a centrifically operated trip causes the main throttle of the steam line to be closed immediately in case of trouble. There are four 300-h. p. water tube boilers installed which operate at 50 lbs. steam pressure. These are equipped with mechanical stokers and a complete system of coal elevating apparatus for bringing the coal from the bunkers below the sidewalk into individual hoppers for each stoker. A pneumatic ash exhauster is installed for blowing ashes from the ash pit into the ash bin on the second floor of the alley side of the building, a total lift of about 60 ft. in height. A 35-h. p. motor is installed which has a capacity for handling eight tons of ashes per hour.

The switchboard has some novel features which are of interest. Any one of the three machines may be operated on the combined light and power circuits or, as will be more generally the case, the light and power circuits may be operated entirely independent of each other. This is effected by means of a heavy double throw switch

and single throw tie switch of 600 ampere capacity mounted on a panel back of the switchboard. The generators are of 220 volt, three wire type, and the various lighting and power circuits throughout the building are so designed as to make an approximate balance on both sides of the neutral. A recording ampere meter is supplied on both sides of the light circuit which will show up any chronically unbalanced condition in the circuits which can then be rectified by changing connections on the individual boards of the floors above.

Fig. 3. Night Illumination in One of the Drafting Rooms.

There are recording kilowatt meters on both power and light circuits and a recording ammeter and a recording volt meter for power circuit and integrating meters registering total kilowatt hours for both power and lighting circuits. A bench board shown on the right hand side of illustration (Fig. 7) is installed for operating the remote control apparatus for both rheostats and generator circuit breakers. There are three indicating lights for each control switch, the white one showing when the motor is operating on the generator circuit control panel, a red light indicates when the breaker

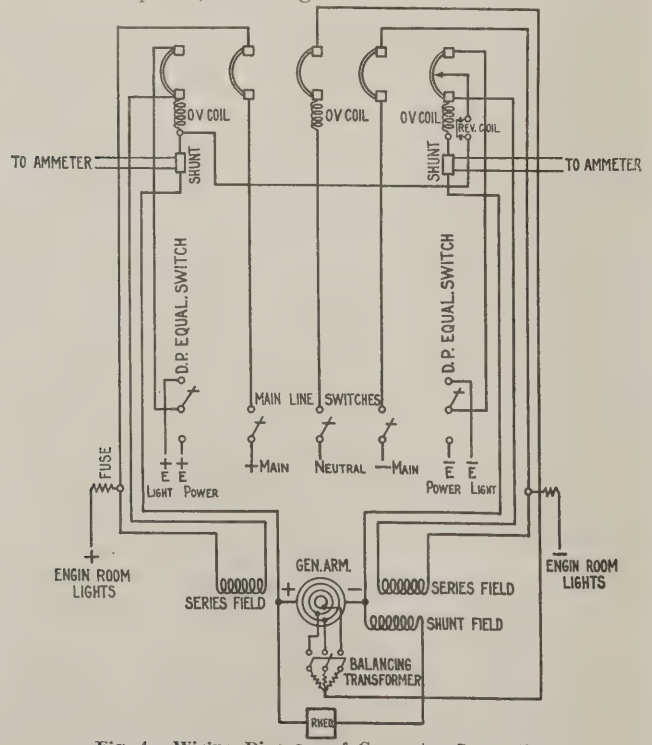


Fig. 4. Wiring Diagram of Generator Connections.

is closed, and the green light indicates when it is open. Two station type volt meters are mounted on the bench boards and are supplied with push button contactors. They may be used to indicate the voltage of any circuit.

Fig. 5. Night Illumination in Telegraph Office.

For the protection and control of each generator there is mounted on a special board, as shown in Fig. 6, a five-pole overload reverse current direct acting time limit motor operated remote control circuit breaker. These panels are mounted adjacent to the generator as

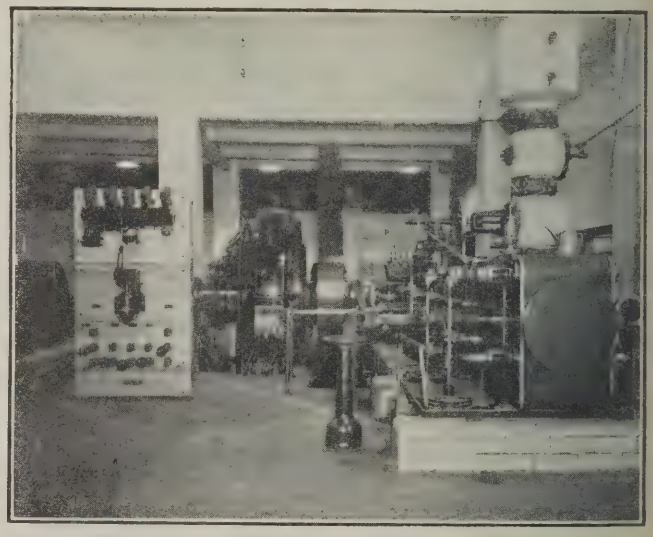


Fig. 6. One of the Engine Driven Units With Remote Control Panel.

shown. In each power circuit there is mounted on the main switchboard a double pole double coil overload direct acting time limit "Directite" circuit breaker. This latter breaker is of a rather unusual design in that one pole of each circuit is mounted above the other and the tripping latches of each half breaker are connected by a vertical rod to insure both poles operating on an overload on either side of the line. This special construction in which the poles of the circuit breaker are mounted vertically above each other simplifies the bus-bar construction at the back of the board, and permits of a more compact design in the bus-bar equipment.

As will be noted from the accompanying diagram (Fig. 4), there are taps for a three phase transformer taken off the direct current armature winding at points 120 degrees apart. These are taken off through collector rings and are connected through a 3-pole switch to one terminal of three transformer windings. The opposite poles of these transformer windings are all connected

together as a star three phase circuit. The neutral of the 220-volt direct current circuit is then attached to the neutral or common point of these three phase transformer coils.

When there is a perfect balance in both sides of the direct current circuit there will be no current flowing through the neutral wire, and there will be only a slight alternating current flowing through the coils of the three phase transformer. This latter is only the equivalent of the open circuit magnetising current of the ordinary transformer. When the direct current circuits become unbalanced, however, so that there is a flow of current through the neutral wire, this traverses the three coils of the balancing transformer and finds its way back to the armature coils of the main generator.

Fig. 7. The Main Switchboard With Bench Board for Remote Control Apparatus on the Right.

Another novel feature of this equipment is that the equalizer current passes through both the overload coils of the five-pole circuit breaker and the ammeter shunt so that the actual amount of current generated is registered on the ammeter and the overload coil receives the total current passing through the windings of the armature.

The double pole equalizer switch is also a novel part of the equipment in that a generator may be combined to equalize with any other generator on either the light or the power circuits. When any one generator is operating on the power circuit alone, and is providing no current for lights, its balancing transformer may be cut out of service by opening the three phase switch.

The five-pole circuit breaker is equipped with three overload tripping coils, one in the positive machine line and in the neutral. The negative overload coil has also a reverse current coil to provide against reversal of current through the generator armature.

The lights in the engine room proper are connected direct to the generators and are entirely independent of any of the circuit breakers or fuses on either the main switchboard or the remote control board. Even if there is such trouble in the external circuit that all the breakers, both machine and individual circuit go out, the engine room lights will not be affected. There are thirty 150-watt tungsten units in Benjamin reflector sockets installed in the engine room.

Specification for the Lighting, Heating and Ventilation of Steel Full Postal Cars

Revised to Dec. 28, 1912, by the U. S. Post Office Dept.

General.

Lighting of postal cars and apartments primarily to be with electricity or gas, where feasable; mantles to be used on gaslights where practicable, with provisions for emergency lighting as hereinafter specified. Fixtures, wiring, battery boxes and their equipment, gas piping, and all other accessories in connection with the lighting system to be as per railway company's standard practice. Each electrically lighted car equipped for axle generator or head-end system of lighting shall be equipped with storage battery of sufficient capacity to furnish for 12 hours the intensity of illumination specified hereinafter without any charging whatever of the battery during this period. Each car using gas or straight storage electricity as the primary system of lighting shall be equipped with storage capacity sufficient to furnish light for 36 hours at the intensity of the illumination specified hereinafter

CONSTRUCTION.

Body of Car.

The light units for illuminating the bag-rack and storage portions of the car shall be located on the center line of the postal apartment. Direct lighting units shall be located at such uniform height that the shadow of the paper boxes is not cast on any bag-rack label, nor higher than approximately 3 inches above the back rod of rack. In no case shall any light unit (except oil lamps, the lowest point of which may be 6 feet 9 inches from the floor) be mounted at a height of less than 7 feet measured from the floor to the lowest point of the light unit. (Spacing between adacent units in the bag-rack portion of the car shall not exceed 8 feet 6 inches in case of any direct system of lighting, nor 14 feet in case of any indirect system.)

Letter Cases.

Light units or illumination of the letter cases shall be mounted at the same height from the floor as the units in the body of the car, and as far from front of the face of the letter case as possible without the body of the distributer throwing any shadow on his work. In standard construction where the letter-case table is 17 inches wide the above distance is 20 inches. Where the car construction does not permit the above distance to be employed, a lesser distance, but not less than 16 inches, may be employed. Separation between adjacent letter-case units shall be such as to provide an illumination intensity at all points within the requirements hereinafter specified.

If an indirect lighting system be employed, the provisions of the above paragraph will be waived. In such case the only requirements imposed for location of units at letter cases are those involved in providing for sufficient vertical and horizontal illumination intensities to meet the provisions of these specifications as hereinafter stated, all units in the car burning. For the purpose of these specifications an indirect system is here defined as any system in which at least 85 per cent. of the horizontal illumination on the 46-inch plane of utilization is

received, either directly or indirectly, by reflection of the light from the deck of the car.

Special Features of Light Units.

In the case of incandescent electric or mantle gas lamps the design of light unit, except letter-case units, shall be such that no portion of the bare lamp filament or the bare mantle is visible to the eye when the unit is observed at an angle of 70° or greater from the nadir. (In general, light units are preferred which emit no light or only a small amount of light between the angles of 50° and 100° from the nadir.)

The control of the lights in the postal department shall be independent of any other lights in the car and the letter-case units shall be controlled independently of any other light units in the postal apartment.

Initial Illumination Values.

All horizontal illumination values shall be taken on plane 46 inches above floor line. Vertical illumination values shall be taken on the vertical plane on the face of letter case as specified below. New lighting installations shall be such as to give initial illumination values within the following limits:

Location.	Minimum, f. c.	Maximum, f. c.
Bag-rack portion:		
Center of car, horizontal	4.70	10.00
Mouth of bags, illumination measured 18 inches from side of car, horizontal	2.50	10.00
Letter cases:		
Over table, horizontal	4.70	16.00
Face of case, vertical	2.08	16.00
Storage portion, not behind obstruction, horizontal, measured not less than 18 inches from side or end of car	2.50	10.00

Illumination requirements at letter cases as above specified shall be entirely fulfilled by letter-case units, other units in the car not burning; but letter case units may be considered as contributing to the specified illumination values for the body of the car.

If globes or reflectors of opal glass, rough crystal glass, prismatic glass, or aluminumized metal, and those giving similar results (excluding heavy density opal with glazed reflecting surface, mirrored glass, porcelain enameled metal, and those giving similar results) be employed, the minimum values specified in the above table may be reduced 20 per cent. and the maximum values increased 20 per cent.

Above illumination values are based on an allowance of 40 per cent. for depreciation in service. Less efficient maintenance must be compensated for by increased initial installation.

If an indirect lighting system be employed, the minimum and maximum values in the above table may be respectively decreased and increased 40 per cent in the bag-rack and storage portions of the car and 25 per cent at the letter-case locations specified in above table.

Emergency Lighting.

An emergency lighting system consisting of candle lamps will be required on all cars lighted primarily by electricity or gas. (A more adequate system of emergency lighting as defined hereinafter may be required.)

OPERATION.

Service Illumination Values.

While the car is in active service the lighting installation shall be maintained at all times to give illumination values not less than the following minimum values:

Location.	Minimum, f. c.
Bag-rack portion:	
Center of car, horizontal	2.80
Mouth of bags, illumination measured 18 inches from side of car, horizontal	1.50
Letter cases:	
Over table, horizontal	2.80
Face of case, vertical	1.25
Storage portion, not behind obstructions, horizontal, measured not less than 18 inches from sides or ends of car	1.50

Illumination requirements at letter cases as above specified shall be entirely fulfilled by letter-case units, other units in the car not burning; but letter-case units may be considered as contributing to the specified illumination values for the body of the car.

If globes or reflectors of opal glass, rough crystal glass, prismatic glass, aluminumized metal, and those giving similar results (excluding heavy density opal with glazed reflecting surface, mirrored glass, porcelain enameled metal, and those giving similar results) be employed, the minimum values specified in the above table may be reduced 20 per cent.

If an indirect lighting system be employed the minimum values in the above table may be decreased 40 per cent. in the bag-rack and storage portions of the car, and 25 per cent. at the letter-case locations specified in the above table.

Light Failure.

A light failure is defined as the condition where for a period exceeding 30 minutes the primary lighting system fails to give sufficient illumination to permit distribution of mail matter to be continued. It will be considered that whenever the lamp voltage falls below 80 per cent. of the normal operating lamp voltage such a condition of light failure has been reached.

Car Movement.

A car movement is defined as the use of a postal car by a crew of postal clerks over the length of their run in one direction. Where a car covers more than the run of one crew, each separate run shall be considered a car movement.

Percentage of Failure.

The percentage of failure of the lighting system is defined as the ratio of the total number of failures to the total number of car movements of each primary system of lighting (gas and electrically lighted cars to be considered separately) on each railway system. The determination of percentage of failure shall be based on the operating performance of each car for the preceding 12 months period. Only such failures as are promptly reported by the Railway Mail Service to the operating railroad shall be considered in computing the percentage of failure.

Emergency Lighting.

If the percentage of failure of the primary system of electric or gas lighting does not exceed 1 per cent., candle lamps will be accepted as a suitable emergency light.

If the percentage of failure of the primary system of gas or electric lighting exceeds 1 per cent. and is not greater than 4 per cent, an emergency system of suitable oil lamps, gas or electric lights, maintained by independent storage capacity, may be required. Such emergency system must provide illumination values of not less than 50 per cent of the minimum operating illu-

mination values specified above for the primary system, with the exception of letter cases and center line of car through bag rack portion where the illumination shall not be less than 60 per cent.

If the percentage of failure of the primary system of electric or gas lighting exceeds 4 per cent., a new installation or a second complete primary system of lighting will be required on cars so failing.

Determination of Illumination Values.

The illumination values herein specified shall be determined by the usual and approved methods. Any differences regarding the same which may arise between the Post Office Department and the railway companies affected shall be referred to the Bureau of Standards for decision.

HEATING.

Heating of postal cars primarily to be with steam or hot water. Pipes are to have suitable protection guards of wire or perforated metal. Pipes located behind paper-rack sections shall not occupy space exceeding 20 inches in height and 4 inches from wall of car. Where service conditions require, an auxiliary coal-burning stove of safety pattern shall be furnished, complete with coal box and firing tools, smokejack properly screened, and protection guards. The stove and coal box to be securely attached.

The train-pipe steam line to be applied and equipped with end valves, steam hose and couplings, as per M. C. B. requirements and the railway company's standard.

Requirements of the department embody three main points: First, sufficient heat to keep the postal car or apartment comfortably warm; second, proper distribution of heat, particularly throughout that part of the car occupied by letter cases and paper racks (care should be taken not to have excess of heat around the letter cases), and third, an arrangement of pipes to avoid interference with distributing facilities.

To obtain the results outlined above the department will require postal cars and apartments to be equipped with sufficient amount of radiation to make the floor of the car comfortable and to obtain a temperature of 65 degrees between the side doors at a point 5 feet above the floor line and to maintain such temperature under the most adverse weather conditions to which the car is subjected when in service. Sufficient radiation should be provided in the end of the car containing hopper and washstand to maintain a temperature of at least 48 degrees in that location.

All coal-burning stoves furnished as an auxiliary or emergency heat must be of a safety pattern or design, properly guarded by metal casing so as to prevent overheating of closely-surrounding objects and damage which might result therefrom.

VENTILATION.

Ventilation of postal cars of clear-story design to be accomplished by means of self-acting ventilators, having intake and exhaust working in conjunction. Four such ventilators per side for 70 and 60 foot cars; three per side in 50 and 40 foot cars, and two per side in mail apartments placed to obtain maximum results. Other deck sash to have clear glass and to be placed in fixed position without screens. Trimmings of deck sash to be railway company's standard.

Postal cars not having clear-story roofs are to have a sufficient equipment of self-acting ventilators in the roof.

THEO. INGALLS,
General Superintendent Railway Mail Service.
JOSEPH STEWART,
Second Assistant Postmaster General.
FRANK H. HITCHCOCK,
Postmaster General.

Postal Car Layouts.

In order to obviate the necessity of each railroad company making extensive illumination tests and numerous trial installations so that they may be sure the illumination in any proposed postal car will comply with the specifications of the Post Office Department, we submit herewith a series of layouts for both the full postal car and the apartment postal car.

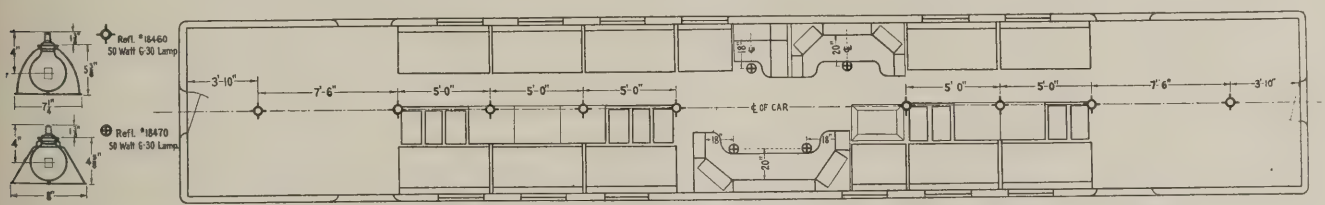


Fig. 1. Layout for Full Postal Car Using 50 Watt Tungsten Lampsand Holophane D'Olier Enameled Steel Reflectors.
(All Units Mounted 7′ 9″ Above the Floor, Measured to the Top of the Reflector.)

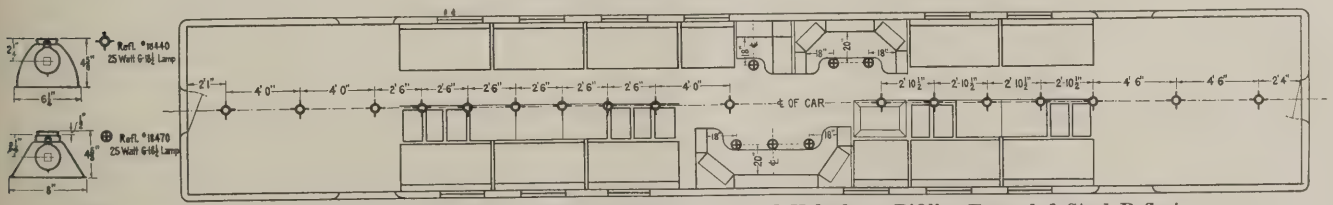


Fig. 2. Layout for Full Postal Car Using 25 Watt Tungsten Lamps and Holophane D'Olier Enameled Steel Reflectors.
(All Units Mounted 7′ 9″ Above the Floor, Measured to the Top of the Reflector.)

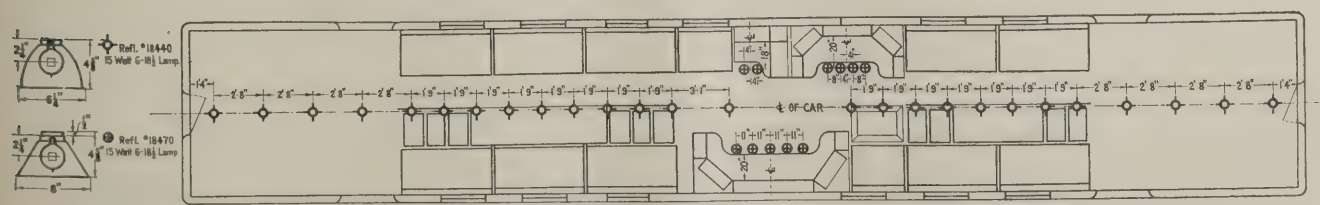


Fig. 3. Layout for Full Postal Car Using 15 Watt Tungsten Lamps and Holaphane O'Olier Enameled Steel Reflectors.
(All Units Mounted 7′ 9″ Above the Floor, Measured to the Top of the Reflector.)

These layouts were designed by Mr. A. J. Sweet, Commercial Engineer of the Holophane Works of the General Electric Company who is one of the first authorities of the country on illumination matters and has made a special study of the illumination of postal cars.

Mr. Sweet has chosen the aluminized metal reflector in all of the accompanying layouts, for with that unit the glare is minimized, yet the efficiency is high and light control excellent. The design of the lighting layouts submitted was based upon the use of this reflector, so these diagrams will apply only where this particular type of shade is employed. Later, however, we hope to be able to publish some layouts using other types of reflectors.

These computations are based upon the use of tungsten lamps (1.25 watts per candle) in the various sizes shown, and the lighting fixtures are to be mounted in every case so that the top of the reflector is 7 ft. 9 in. above the floor.

It will be noted from the accompanying diagrams of full postal cars, that where the 50 watt lamps are employed it requires 13 lamps (650 watts) per car in order to meet the specifications, while with the 25 watt lamp it requires 23 lamps (575 watts) per car and with a 15 watt lamp it requires 37 lamps (555 watts) per car. The reason for this is that the 25 watt lamp can be spaced very much more economically than the 50 watt lamp, and the 15 watt lamp more economically than the 25 watt lamp.

Special attention, however, must be called to the matter of the type of reflector used. With the various types of reflectors on the market, low grade and high grade, there can easily be a difference as great as two to one in the illumination produced on the reading plane of the car. These layouts are based upon the use of the illuminized metal reflector which has a high efficiency.

It will be noted that the specification requires that the storage battery capacity on cars equipped with axle devices be sufficient to maintain the specified illumination for a period of 12 hours. This on the 650 watt car would amount to 20 amperes for 12 hours at 30 volts or 240 ampere hours required to meet the specification. The standard 280 ampere hour storage battery would then meet the specification when new, but it must be remembered that a storage battery loses its capacity somewhat as it grows older, so in order to make provision against this loss of capacity or other emergencies it will probably be found necessary to install two storage batteries of the standard 280 hour capacity on each postal car.

THE WESTERN ELECTRIC COMPANY IN 1912.

On account of the world-wide ramifications of the Western Electric Company the final figures as to the results of the year 1912 will not be completed much before April 1st. The sales will be between 71 and 72 millions, which is slightly more than in 1906, the previous largest year in the Company's business. The increase has been in American sales outside of the Bell System, which have increased about 100 per cent. over 1906, and in European sales, which were the largest in the Company's history. The results have been accomplished by an energetic selling campaign in the face of increased and increasing competition.

The Company is now selling to upwards of 30,000 customers in the United States alone.

It is expected that the profits will be satisfactory considering the wider distribution and increased competition.

The Board of Directors has established two additional vice-presidents in the company's organization, and has appointed to these newly created positions Gerard Swope, General Sales Manager, and A. L. Salt, General Purchasing Agent.

LARGE AREA LIGHTING.

This is the title of a pamphlet just issued by the General Electric Company giving data and other information on the new long burning flame arc. The booklet shows details of the lamp and also a photograph of an installation in a large car shop.

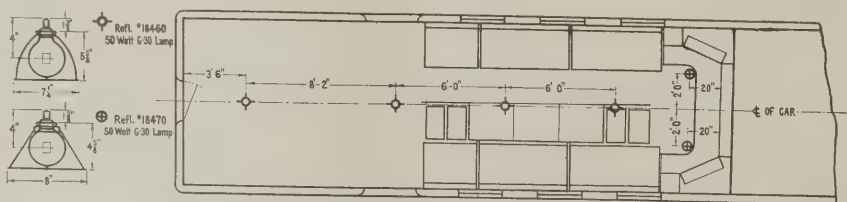


Fig. 4. Layout for Apartment Postal Car Using 50 Watt Tungsten Lamps and Holophane D'Olier Enameled Steel Reflectors.
(All Units Mounted 7' 9" Above the Floor, Measured to the Top of the Reflector.)

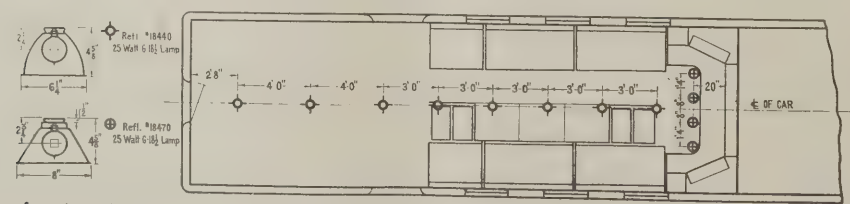


Fig. 5. Layout for Apartment Postal Car Using 25 Watt Tungsten Lamps and Holophane D'Olier Enameled Steel Reflectors.
(All Units Mounted 7' 9" Above the Floor, Measured to the Top of the Reflector.)

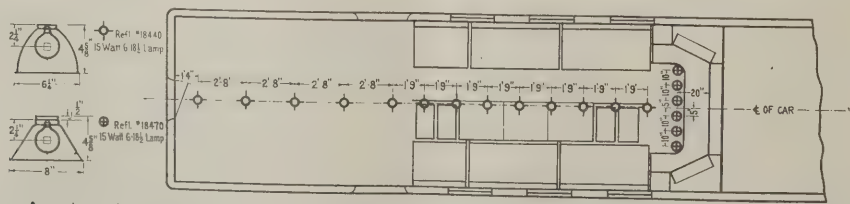


Fig. 6. Layout for Apartment Postal Car Using 15 Watt Tungsten Lamps and Holophane D'Olier Enameled Steel Reflectors.
(All Units Mounted 7' 9" Above the Floor, Measured to the Top of the Reflector.)

The Quartz Tube Lamp in Railroad Service

With the development of the quartz tube mercury vapor lamp to a commercial stage very recently, the attention of all electrical men, particularly those associated with large manufacturing and railroad interests, has been drawn toward this lamp with a view to using it in large erecting shops where a general illumination is desired and where traveling cranes compel that the lighting units be mounted 50 to 60 ft. above the floor. It also finds a wide application in yard and station lighting.

Numerous installations of this type of unit have already been made, one of which, installed in the locomotive erecting bay of the railroad shops of one of the big eastern roads, is shown in the accompanying illustrations.

This shop is 68 ft. wide and 264 ft. long. Lamps are mounted 64 ft. above the floor so as to clear the cranes, and are placed in a row down the center of the shop at a spacing of 58 ft. between lamps. An illumination test was made, the 18 test stations being so laid out as to obtain average illumination over the entire floor space.

The following data was observed:

Size of shop	68 ft. x 264 ft.
Area	17,950 sq. ft.
Ht. of lamps	64 ft.
Ht. of readings	42 in.
Photometer Constant	.204

Station.	Reading.
1	2.10
2	3.35
3	4.39
4	2.08
5	3.52
6	4.48
7	2.57
8	3.48
9	3.69
10	3.12
11	7.16
12	4.80
13	2.98
14	3.51
15	4.00
16	2.68
17	3.69
18	4.23

Average 3.49 x .204 = .711 ft. candles.

Amperes (4 lamps)	12
Volts	234
Watts	2808

$$\frac{\text{2808 Watts}}{\text{17,950 sq. ft.}} = .156 \text{ Watts per sq. ft.}$$

$$\frac{\text{.156 Watts per sq. ft.}}{\text{.711 ft. candles}} = \text{.22 Watts per sq. ft. per ft. candle.}$$

At the time this test was made there were no reflectors installed on the lamps. The addition of these reflectors as now installed on all lamps will increase the illumination value given above between 15 and 20%.

The light from this new quartz lamp, although much whiter and containing more of the purple and red rays than the long tube mercury vapor lamp, seems to retain to a marked degree the excellent seeing qualities of the mono-chromatic light of the original Cooper-Hewitt lamp. This is fairly well shown by the sharp contrast in the small details of the night view which is much more marked than in the day picture.

In principle of operation of the new lamp is essentially similar to the long tube mercury vapor lamp, the only difference being that, while the standard Cooper-Hewitt lamp is operated at the pressure equal to about one-eighth of an inch of mercury column (representing a fairly high vacuum) the gas pressure in an operating quartz lamp may be that of atmosphere or even higher. The result is that it requires a much higher voltage per lineal inch of tube to operate the new lamp, and accordingly the tubes are made very short. The temperature of the luminous vapor in this lamp is extremely high (7000 deg. C.). An ordinary glass tube would be easily melted, so special tubes made of pure fused quartz which requires the oxyhydrogen blow pipe to fuse it are employed.

Quartz has the peculiar property of zero temperature coefficient of expansion, so does not crack when heated suddenly; it is fairly tough, and will withstand very high temperatures without melting, so is an admirable material for use in these lamps. The laborious process of fusing the pieces of quartz together, however, makes these tubes rather expensive. The form of the tubes is shown in the accompanying illustration and diagrams.

Tube (t) forms the path of the luminous vapor and terminates at the positive end in an enlarged bulb (p), and at the negative end in a large lateral tube (n). There is a small amount of mercury in each end compartment and this forms the two electrodes which receive the electrical energy through the small upright tubes S1 and S2. Rods of special alloy slightly conical in shape are ground into the walls of these upright tubes and the joints are covered with mercury, which in turn is closed in by a layer of suitable compound. This prevents the access of air when cold or the emission of gases from the interior, when operating at full temperature and the vapor pressure of the mercury is at a maximum.

When a cool quartz lamp is first started the pressure within the tube is very low and accordingly there is a heavy current flow due to this low gas pressure. At this time the whole cross section of the luminous tube is filled with the pale blueish green light. Presently, however, as the lamp warms up the appearance changes and the current falls off as shown in the diagram, Fig. 4. The voltage across the burner rises as the current falls. The light then begins to recede from the walls of the tube, and as the vapor pressure of the mercury increases, due to the increased temperature, it becomes concentrated in the center of the tube in a small but brilliantly illuminated band of light. The light then assumes a white color and the increase in red and orange rays is clearly evident as the lamp attains its normal temperature of operation.

When the lamp is not in use the quartz tube is inclined so that the mercury makes contact between the two electrodes and short circuits the burner. When the line switch is turned on this short circuiting current magnetizes the solenoid (m), which actuates the movable armature and tips the tube, breaking the contact

between mercury electrodes and striking the arc. As long as the lamp is in use the tube is held in this position, but upon switching off the light the tube is allowed to fall into an inclined position and mercury contact between electrodes in the tube re-established. In order to avoid sudden shocks to the movable parts in closing or opening the circuit, an air dash post (d) is connected to the armature of the operating magnet. In order to maintain the current flowing through the tube at normal value a resistor is employed and also a series inductor the winding of the lifting coil (m) for steadying the arc. The quartz tube burner, the resistor, and the lifting coil (m) are all connected in series.

Fig. 1—The Locomotive Erecting Bay Under Daylight Conditions.

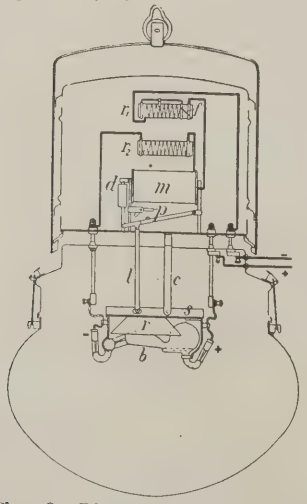


Fig. 2. Diagram of 110 Volt 4 Amp. Lamp.

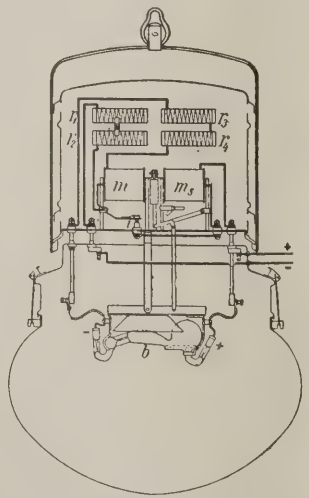


Fig. 3. Diagram of 220 Volt 3.5 Amp. Lamp.

The lamp is made in both 110 volt and 220 volt types, which are almost identical in operation and design. It is intended for operation on direct current circuits only, but may be operated from an alternating current supply by using a rectifier. A small movable permanent magnet (p) is supplied for the purpose of automatically locking the tilting device when the polarity at the lamp terminals is reversed, and so protects the burner against being ruined by a reversal of polarity. An inverted white enamel trough reflector is supplied which redirects the rays of light to a useful downward direction. This intercepts all light above an angle of 50 per cent. from the nadir. Although the ultra violet rays of incandescent mercury vapor which are injurious to the eyes at close range are readily transmitted through the quartz tube, they are entirely intercepted by the common glass enclosing globe surrounding the tube. This also serves to protect the burner from a free circulation of air which might cool off the tube too rapidly and in lowering its temperature, lower the vapor pressure within the tube and cause a corresponding increase in current flow.

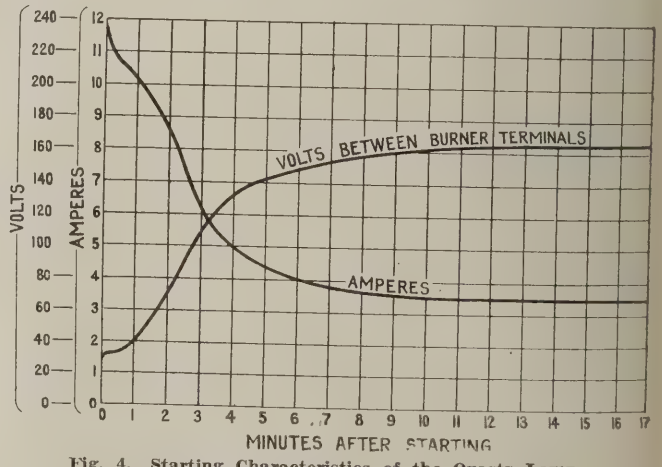


Fig. 4. Starting Characteristics of the Quartz Lamp.

The temperature of the thin luminous band of light in the center of the tube is estimated by various authorities at between 6000 and 7000 degrees C. This is far above any temperature ever obtained by any other means. The temperature of an arc or electric furnace is limited by the temperature of vaporization of the carbon or other conducting material. In other words, as long as there is any solid or liquid matter present which can be vaporized, the temperature of the arc will not rise above the temperature of vaporization of carbon. This is approximately 3600 degrees.

In the case of the quartz tube lamp, however, where the arc is very much longer than the ordinary arc, and where the conducting material is vaporized mercury, the heat due to the flow of electric current cannot be dissipated in volatilizing any solid matter, hence, the temperature of the vapor can rise to an exceedingly high value. This is probably one of the causes of the high efficiency of the quartz tube lamp.

The manufacturers state that the experience of a large number of lamps now in service would indicate that the average life of lamps is between 3,000 and 4,000 hours. When a lamp fails, however, it does not necessarily mean that the burner is entirely useless; this is often due simply to a loss of vacuum which makes it difficult to strike the arc, or to a crack in the quartz tube itself which is often easily patched, the burner repumped and made ready for service. Even when the burner is badly demonished, the pieces of quartz have a considerable scrap value.

Fig. 5. The Locomotive Erecting Bay Under Night Illumination.

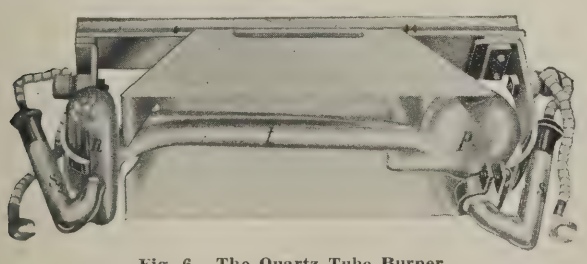


Fig. 6. The Quartz Tube Burner.

NEW TELEPHONE EQUIPMENT FOR ROCK ISLAND.

The Chicago, Rock Island and Pacific Railway Company recently placed an order with the Western Electric Company for apparatus to be used in extending its telephone train dispatching circuits. The successful operation of the present lines and the economy resulting therefrom have been the incentive for the extension.

Two circuits are to be equipped. One is intended for train dispatching service and will be installed between Des Moines, Iowa, and Trenton, Missouri. The other will be used as a short haul talking and message circuit between Davenport, Iowa, and Rock Island, Illinois, including the yard district in the latter territory. The length of the line in the first named case is approximately 110 miles, while the latter is about 5 miles.

The new installation will consist of two complete dispatcher's equipments, twenty-one No. 102 type selector sets containing the standard Western Electric No. 50 selector. The transmission apparatus at way stations will consist of the new self-contained, "folding-gate" No. 1048 type telephone arm. Miscellaneous equipment and line material is also being furnished.

Electrification of the Victorian Rys. at Melbourne

Probably the most notable railway electrification project at the present time is that about to be undertaken in connection with the suburban steam railways of Melbourne, Australia. The advisability of the step has been under consideration for a number of years, and in 1908 Mr. Charles H. Merz of the firm of Messrs. Merz & McLellan, Victoria street, Westminster, London, presented a comprehensive report on the subject to the Victorian Railway Commission. In this report Mr. Merz, acting as consulting engineer on the scheme, went very fully into the whole question of the substitution of electric traction on steam railways.

Since that time a number of important railways have been electrified in all parts of the world, and experience has demonstrated the great advantages and economies which result from this mode of operation. In this particular case, the rapid growth of the suburban business in and out of Melbourne was also a decisive factor that emphasized forcibly the need for electrification. Recent practice especially has shown that the adoption of the high voltage direct current system by a number of roads has resulted in eminently successful and exceptionally economical operation both for suburban and through service.

In a later report, embodying a comparative analysis of the merits of both the single phase alternating current and high voltage direct current systems, based on the tenders submitted, Mr. Merz points out that the adoption of the high tension direct current system for this application would mean a saving of about $3,500,000, or nearly 30 per cent., in the cost of installation over that of the single phase system. Accordingly, in view of this initial saving and a further operating economy, as indicated by Mr. Merz, of about $350,000 per annum, or nearly 28 per cent., he recommended very strongly the adoption of the high tension direct current system for the Melbourne railways, and the Victorian Government accepted his recommendations.

Melbourne, the capital of the State of Victoria, is situated in the southern part of eastern Australia on the Yarra River, eight miles from its mouth at the head of Port Philip. The river is accessible for vessels drawing 22 feet of water, and all larger vessels are easily accommodated at Port Melbourne in Hobson Bay. Along the river are large docks, shipyards, foundries and manufacturing plants representing a number of industries. The city has a population including its suburbs of over half a million, and is the most important municipality and the greatest trade emporium in Australia.

The electrification of the Melbourne Suburban Railways is of exceptional interest because it will be one of the largest projects of its kind in the world, involving heavy rolling stock equipment with overhead collectors. The magnitude of the undertaking from the standpoint of equipment and service may be compared with that on the third rail electrified section of the New York Central Railroad out of New York City, and ranks with the Oakland, Alameda & Berkeley electrification of the Southern Pacific Railroad at San Francisco.

Naturally, the great size and tremendous importance of the project attracted world-wide competition, and among the leading manufacturers of electrical apparatus submitting tenders are included the Allgemeine Electricitaets Gesellschaft, Berlin; British Westinghouse Co., Manchester; Dick Kerr & Co., Ltd., London; Ferranti, Ltd., Hollinwood; Siemens Bros. Dynamo Works, Ltd., London; General Electric Company of New York, and others. After an exhaustive study and consideration of the relative merits of the several propositions, Mr. Merz approved in his report the recommendations of the General Electric Company of New York as to choice of system and economical features of operation, and the Victorian Government awarded this Company the contract for the rolling stock apparatus equipment, comprising 400 motor car equipments, consisting of four motors each; 800 control equipments, 400 of which are for trailer cars, and 400 air compressor equipments. This is the largest single order ever placed for electric railway apparatus.

The mileage of the suburban lines included in the scheme is made up of 150 route-miles, or 289 track-miles of running roads, and 34 miles of sidings. The potential selected for this direct current system is 1500 volts. Power will be supplied from a central station at Yarraville, a suburb of Melbourne, in the form of three phase alternating current at 25 cycles per second and will be transmitted at 20,000 volts to twelve sub-stations at various points on the system, where it will be converted into the operating direct current of 1500 volts. The high tension transmission is by underground cables from the power house to the important sub-stations in the central area, and by overhead wires erected on the same structures which carry the railway track conductors to the outlaying sub-stations. Overhead conductors will be used throughout the system for supplying current to the trains, which will be equipped with roller pantograph collectors. The complete equipment of the railways involves the expenditure of $12,000,000 in round numbers, and Mr. Merz figures the saving of electric operation will amount to about $600,000 in 1915 over the former steam operated lines.

Normal trains, weighing about 180 tons, will consist of two motor coaches and two trailer coaches. The tracks are 5-ft., 3-in. gauge. The suburban traffic amounted to 70,000,000 passengers in 1908; the figure the past year exceeds 90,000,000; and in 1917, when it is expected that the conversion to electric operation will be entirely completed, it is estimated that the suburban lines will carry 150,000,000 passengers per annum. The present plans are accordingly based on provision for this probable increase in the passenger traffic; but all parts of the electrification scheme are arranged so as to be capable of extension from time to time, as the traffic subsequently grows. Handling heavy traffic during the rush hours of morning and evening will be provided for by increasing the length of trains, although for this initial service it is the intention to have the maximum train consist of six coaches.

The method of self-ventilation which will be incorporated in the design of these motors will assure exceptionally effective and uniform cooling. This will be accomplished by a broad-bladed centrifugal fan cast integral with the pinion end armature core head. Fresh air is drawn into the interior through a screened opening on the upper side of the motor frame at the pinion end. This is circulated over the armature and field coils, under and through the commutator, through longitudinal holes in the armature core, and thence exhausted to the exterior through openings in the pinion end bearing head.

Scientifically correct in principle, this method of ven-

tilation has been demonstrated through service tests to be the most successful manner of securing evenly distributed cooling; for without complication it circulates effectively a large volume of cool air throughout the motor and keeps all parts at a uniform temperature, eliminating the possibility of "hot spots." The service

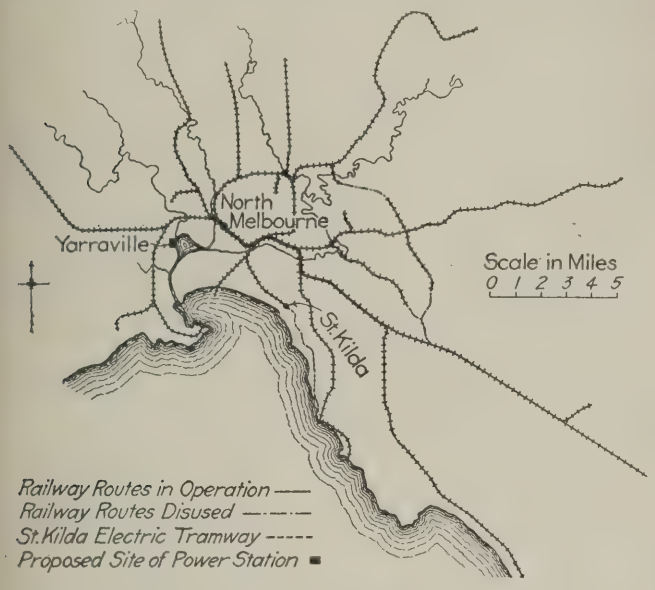


Fig. 1. The Suburban Railways of Melbourne to be Electrified.

capacity of the motor, due to its ventilation, is rendered much greater than that of an ordinary motor of the same nominal rating. At the same time the weight per horse power is greatly reduced without sacrificing mechanical strength, durability or electrical efficiency.

The service on the lines calls for both local and express schedules. The motors will therefore be arranged for tap field control, which will allow a free running speed of 52 miles per hour over level track for the suburban cars and express runs. This method of auxiliary control was introduced by the General Electric Company a number of years ago, but due to commutating limitations of earlier motors, it was eventually abandoned. Its successful application to commutating pole motors is therefore modern.

The principal advantages to be derived from tap field control are increased operating efficiency, continuous saving of power, ecenomy effected through decrease in the weight of the equipment and an increase in the service capacity. The practical effect of tapping the field is to eliminate one resistance step and to secure the desired accelerating effort throughout from start to full speed with a lower current input.

The GE-237 direct current motor selected for these equipments is designed especially to obtain low energy consumption. This comparison of energy consumption is included in Mr. Merz' report in the number of kilowatt-hours required by a four-coach train making a round trip between Sandringham and Broadmeadows. Based on the several manufacturers' guarantees, Mr. Merz arrives at an economy of 23 per cent. in energy consumption in favor of the high tension direct current equipment.

Other points that were brought out as being adverse to the single phase system for this application might be mentioned: as follows, slightly reduced seating capacity of the trains on account of the extra amount of room required by the single phase equipments; the extra wear on the track rails due to the extra dead weight of the single phase motors, and the extra amount of spare plant required in connection with the single phase scheme on account of the greater complexity of the equipments. As we have indicated, Mr. Merz estimated that the annual operating cost of the single phase system would be about $350,000, or nearly 28 per cent., more than for the direct current system, and he also came to the conclusion that the latter system would show an increasing advantage over the single phase system as the traffic becomes greater year by year.

Electrification of steam roads both here and abroad has emphasized the fact that the conversion to electrical operation is always accompanied by a faster and more frequent train service, and because of greater convenience, comfort and cleanliness, a general improvement in suburban traveling conditions, while the reduction in working cost and the increased earnings of the line combine to produce larger profits.

AN EXTRAORDINARY SHIPMENT OF ELECTRIC LOCOMOTIVES.

Recently an interesting sight was the shipment of ten electric locomotives in the same train across the Alleghanies from Philadelphia to East Pittsburgh. These locomotives are the last ten of an order of thirty-nine, for the N. Y. N. H. & H. R. R., and were shipped to the Westinghouse Electric & Mfg. Company at East Pittsburgh to be electrically equipped.

A Shipment of Ten Electric Locomotives for the N.Y.N.H., & H.R.R.

The mechanical parts were built by the Baldwin Locomotive Works. These locomotives are of the twin-motor articulated type and each is to be equipped with eight Westinghouse Single-Phase Railway Motors and unit switch control.

Twenty-nine similar locomotives are built and building for the New Haven System.

Roller Bearings for Axle Lighting Generators

Curt Langnickel.

EDITOR'S NOTE.

This is the second of a series of educational talks on the subject of anti-friction bearings written by certain authorities on this subject who are connected with some of the various bearing manufacturers.

When the researches of Prof. Stribeck determined the laws of the anti-friction ball bearings, a form of ball bearing was ready and was at once appreciated by both the manufacturing and using engineers; and it was put into practical service at once, superseding all imperfect ball and roller bearing types existing at that time.

The ball bearing was a long time finding its proper place and use; and during this time, many applications were made where the working conditions went quite beyond the capacity of any possible type of ball bearing, so that failure and disappointment were sometimes experienced.

The development of the roller bearing, with its unquestionably possible higher working range, was neglected for some time because the principles for a true anti-friction roller bearing were as little understood as had been those of the ball bearing before Prof. Stribeck's investigations. The Norma Compagnie,* G.m.b.H. of Cannstatt, Germany, however, took up the question of roller bearings and began a research into fundamental principles, which established laws of roller bearing practice as definitely as had been previously laid down for ball bearings. The causes of the frequent failure of roller bearings previous to this were discovered and eliminated in the improved bearing.

The lack of rigidity in machine frames and shafts, and the errors common in aligning during assembling, made the double line contact of the plain roller bearing problematical in most cases of application. The guiding or carrying of the rollers at their ends also resulted in their running out of parallel, otherwise known as skewing. It is not surprising, therefore, that the early roller bearings failed where it was the intention that they should have a performance superior to ball bearings. These conditions led the Norma Company to develop a bearing with a self-aligning feature, safeguarding against errors in application and use.

This feature was obtained by providing slight freedom for the roller ends to swing free by the reomval of light sections of material at both sides, still permiting the rapid expansion of bearing surface under load; and the "crowned" outer race resulted. It was also borne in mind that a roller bearing intended to carry many times the load of ball bearings under equal and even higher speeds must create no speed differences at the lines of contact. The importance of absence of speed differences may be illustrated in order to show that the Norma Roller Bearing is the most perfect anti-friction bearing possible.

Reference to the diagrams herewith (Nos. 1 & 2) show how ball bearing principles and anti-friction bearing principles represented by curves of different characteristics compare in anti-friction qualities. In order to afford some standard of comparison, let us observe the characteristics of these curves in relation to an annular bearing system. It is indeed possible to devise a number of curves all alike in the fact that for a given depression or deformation "x" an equal length of contact "y" is produced.

*Mr. E. G. Hoffman, the inventor of the famous Hoffman ball grinding machine, was one of the founders of the Norma Compagnie. G.m.b.H., and it is this company that has developed the Hoffman ball grinding machines to their present state of perfection of precision.

These two bearing principles here illustrated are identical in their unloaded state, that is, they have a point contact (the point contact being admitted for the sake of argument). The important thing is to know how these different forms perform under heavy load, that is, when the length of contact is increased by local pressure.

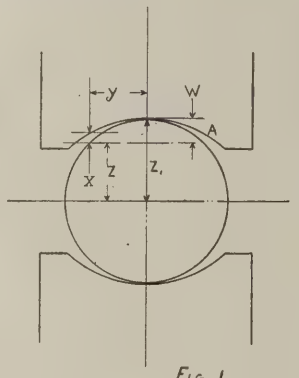


FIG. 1.

Fig. 1. Diagram of Ball Bearing.

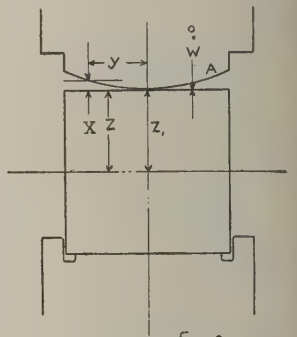


FIG. 2.

Fig. 2. Diagram of Roller Bearing.

In all these bearing forms it is also to be understood that the shape of the rolling element is not sensibly changed by elastic deformation because of the greater structural rigidity afforded by its form. The number of rolling elements need not be taken into consideration, as they refer only to applications for specific pressures, —a point which will be mentioned later.

Fig. 3. Section Through Norma Bearing.

In producing the elastic deformation, it is important to observe whether or no Z and Z_1 have different values. The construction in which $Z=Z_1$ is the one in which speed differences least result under pressure or load. It will be seen that in deforming the curves A, which represent a race in anti-friction bearings, Fig. No. 2 is the one in which the values of Z and Z_1 practically do not vary, thereby indicating that all points inside the distance "Y" have equal speed and roll practically mathematically true. In Fig. 1, on the contrary, it is evident that a considerable addition "W" is necessary in order to make $Z=Z_1$. This addition represents the percentage of sliding friction, differentiating the antifriction values in planes Z and Z_1. For Fig. No. 1 it must be remembered that speed differences of the inner race must be regarded also, whereas the Norma Roller Bearing inner race has a long undisturbed line contact. It will be mentioned when treating the retainer why this contact is undisturbed.

It is evident that in Fig. No. 1 additional load carrying surface can come into engagement only under an increasing sliding friction; and that any effort to strengthen the ball bearing beyond the limits originally determined by Prof. Stribeck is at the sacrifice of anti-friction qualities, which means a shortened life.

Every ball bearing represents a certain amount of working capacity, which can be brought to expression by more embracing races, higher loads and natural lim-

itations in speed, or by less embracing races, lower loads and an equivalent increase of speed.

Increasing speed in the first instance and load in the second will soon show the limitations of both applied principles.

The resulting performance is in both cases approximately the same value for equal sizes. This of course anticipates that material and workmanship are of equal quality in both cases.

ing sufficient to meet all errors in ordinary practice. This rocking or self-aligning does not interfere with perfect load carrying. A clearance of less than 1/2500 of an inch plus the elastic deformation gives the necessary freedom.

As the Norma Roller Bearing is not a thrust-taking bearing, nothing disturbs the rollers and the work performed by the cage is of the lightest character, simply holding the rollers at a fixed distance after engagement

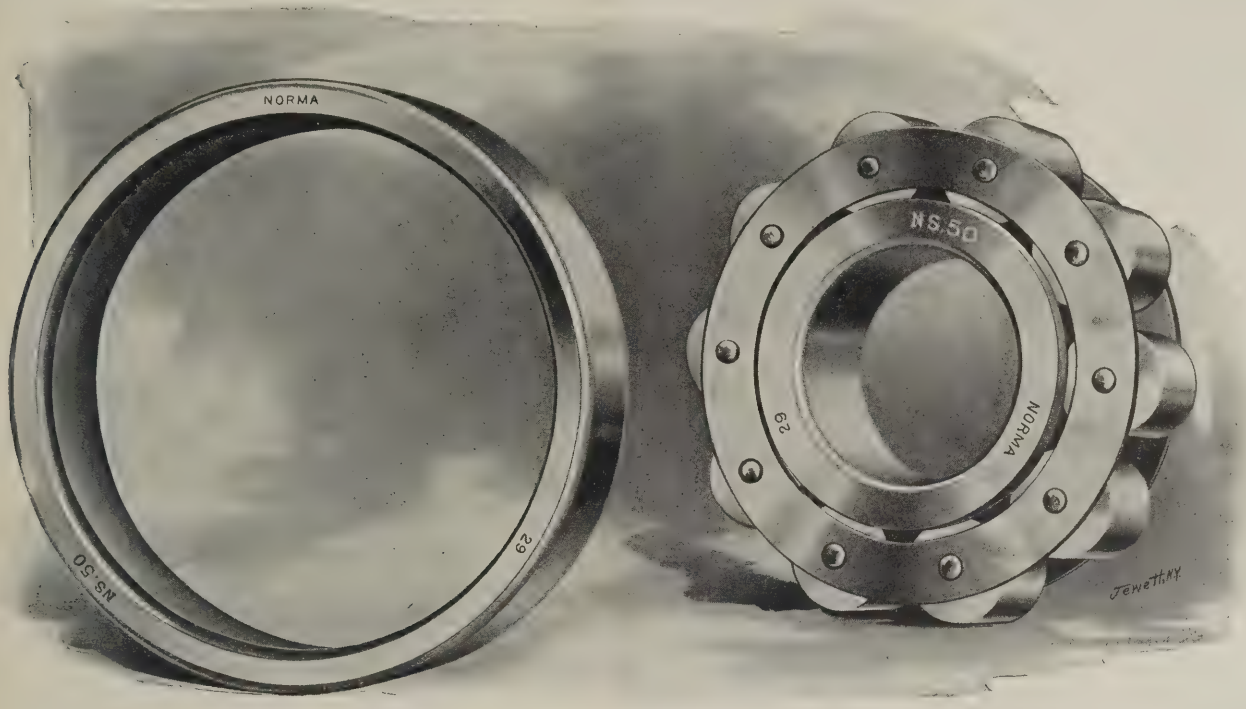


Fig. 4. Norma Roller Bearing with Inner Race and Rallers Removed from Outer Race.

Fig. 2 is embodied in the Norma Roller Bearing and offers the hitherto unknown advantage of taking temporary overloads even beyond 50 per cent of the normal load rating, due to the rapid increase of surface under absence of friction. The normal rating of the Norma Roller Bearing is already twice the rating of a standard annular ball bearing of equal size; and therefore these bearings have a working range three times that of the standard ball bearing. This overload is to be assumed in the form of heavy shocks and vibration.

The Norma Roller Bearing is of the open type and permits the use of any desired number of rollers. For instance, the No. 412 size is equipped with twelve one-inch rollers.

This extremely favorable number of rollers combined with the high degree of accuracy in manufacturing creates a condition under which the Norma Roller Bearing works under lower specific pressure than any ball bearing of corresponding size, hence the overload capacity.

It was essential to produce short rollers on a commercial scale of a standard of accuracy equal to the famous Hoffmann steel balls, that is, rollers of true cylindrical shape, varying not more than plus or minus 1/10,000 of an inch in diameter.

It was understood that a roller of the Norma type would permit a more conclusive test against the presence of slag veins or other defects in the material, which are difficult to detect in balls. Because of the hollow cylindrical form, a strong radial pressure on the roller will reveal any weakness of material.

The inner system of the bearing, standing on the crowned outer race surface, will permit a slight rock-ceases. This conduct of roller and cage is of importance in connection with the positive safety of rollers against breaking. The rollers are guided under freedom at their center with a minimum contact speed. The natural tendency to travel under least resistance makes them select the position in parallel with the axis of the inner cylindrical race, thereby escaping all tendency to skew. In addition, axial errors in machining and assembling are easily taken care of by the open type of this bearing and a thorough inspection is possible before mounting and, if desirable, during general car repairs.

All these features of strength are believed by the Norma Company of America to recommend these bearings for use in axle lighting generator service. It is an ideal bearing for the taking of heavy and irregular belt pull and the shocks experienced in lighting generators. In application it can be advantageously used in connection with a ball bearing, taking the thrust at the idling end of the generator.

PROPER LAMP VOLTAGES.

This is the title of a new bulletin issued January 1st by the Engineering Research Department of the National Electric Lamp Association. The bulletin deals with those technical relations between line voltage and lamp voltage, upon which depends the selection of a proper lamp for any circuit. An incandescent lamp consumes its rated wattage, gives its rated candle power and lives its rated life only when supplied with current at a voltage equal to the rated voltage of the lamp.

This bulletin has much information of technical value on this broad subject.

The Telephone Fire Alarm System

David D. Gee.

The fire alarm system of a railroad shop is of grave importance and oftentimes the safety of the entire shop depends upon its successful working. The following is a desription of a telephone fire alarm system operating in Rochester, N. Y., and at present being installed in a number of western cities by the American Telephone Fire Alarm Company of Chicago.

General Description.

This system is designed to provide means in case of a fire for the prompt transmission of code signals over ordinary metallic telephone lines to the telephone central office and thence to fire headquarters.

It gives the exact location and nature of the building from which the alarm is being sent, enabling the attendant at fire headquarters to intelligently despatch the necessary fire fighting apparatus.

The instruments which are furnished at each building consist of small metal boxes containing special push-buttons and a box containing a special form of transmitter. In residences there is but one signal station installed, the push button and the transmitter are combined into a single instrument. In factory equipments, relays, gongs and annunciators are also employed. A hammer attached to each box affords means of breaking the glass protecting the push-button.

The system therefore, may be used either with one signal station in a building with a multiplicity of such stations, from any one of which signals may be sent over the outside telephone lines. The first of these adaptations will be referred to as the Single Station Equipment, and the second as the Shop Equipment. Each adaptation may be used on either manual, automatic or magneto telephone systems.

Single Station Equipment.

Upon the operation of the manual box bridged on a telephone line connected with a common battery manual telephone exchange, the call comes in to the telephone operator with a flashing signal. The telephone operator answers the call and upon doing so receives a distinctive bell signal which cannot be misunderstood. This denotes a fire alarm call. The operator withdraws the answering plug and inserts in this line the special fire plug, thereby connecting the fire alarm call to the register circuit, the registers being located at fire headquarters and upon the telephone chief operator's desk. The registers and tapping bells at both fire headquarters and chief operator's desk in telephone office are in series, the circuit using the telephone exchange storage battery and being under a small current test at all times.

Two Alarms at One Time.

When a telephone operator inserts a fire plug, in the telephone line from which the first alarm is received, all other fire plugs on the switchboard are automatically switched to a second register circuit, the register being located at the telephone office. This second register circuit is tested twice daily.

Shop Equipment (Normal Operation.)

In shop installations the building is equipped with manual stations, any number installed on each floor as desired.

One transmitter box is used and a separate circuit for the manuals for each floor, all circuits being common to the transmitter box. By means of test relays this entire circuit is kept under constant test. Included in this circuit is an annunciator showing each floor. A relay operates the loal fire alarm bell circuit, bells being rung at the annunciator and upon each floor of the building, if desired, upon the operation of any manual station.

Fire Drill.

A fire drill is provided by having all fire alarm bells sounded, giving a code signal. This usually consists of four strokes denoting fire. This signal may be given by someone in charge as a test fire drill, being operated independently of the fire alarm system. These bells are also controlled by a mechanism which operates with the fire alarm transmitter when any normal box is operated in the event of fire. If desired, the location of the fire in the building may be given by code signal.

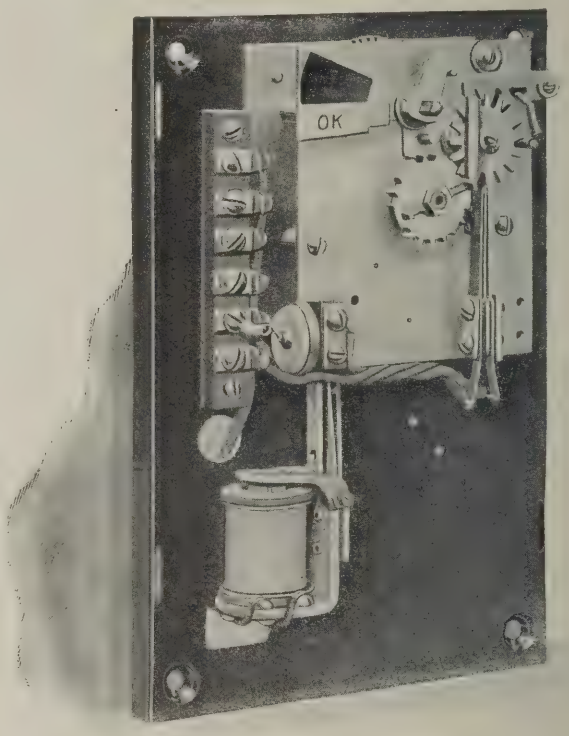


Fig. 1. Interior of Transmitter.

Thermostats.

Any standard type of open circuit thermostat may be used in conjunction with this system. The usual plan is to have them connected in pairs, one set at 120 degrees Far., and the other at 160 degrees Far. A rise in temperature sufficient to operate the first thermostat would give a local alarm in the building notifying the attendant. A further rise in temperature would operate the other thermostat of the pair ringing the local alarm bells operating the annunciator and sending in fire alarm call to fire headquarters.

Sprinkler Alarms.

Connection may be made to the gate valve alarm on a sprinkler system so that in the event of a sprinkler head being operated, in addition to giving the local alarm, the fire alarm call would be transmitted.

Trouble Signals.

These are provided for only in the shop equipments, since only in this type of installation is there any inter-

ior wiring at the building other than the ordinary telephone lines.

The circuit in the building is normally closed and gives immediate signal upon the appearance of trouble, viz., a break in any portion of the circuit, a ground on either side of the circuit or failure of the gravity battery.

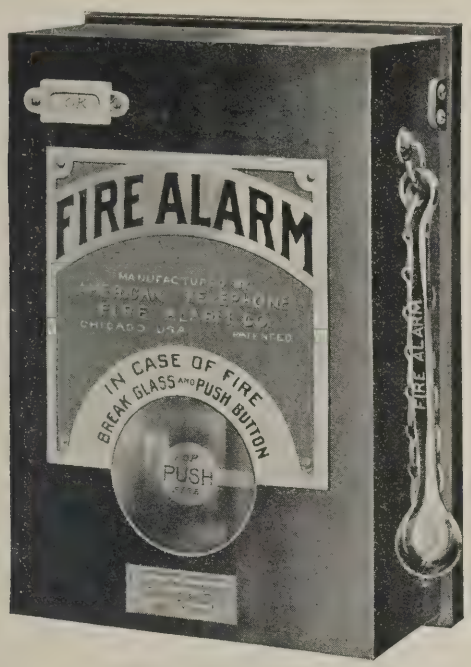
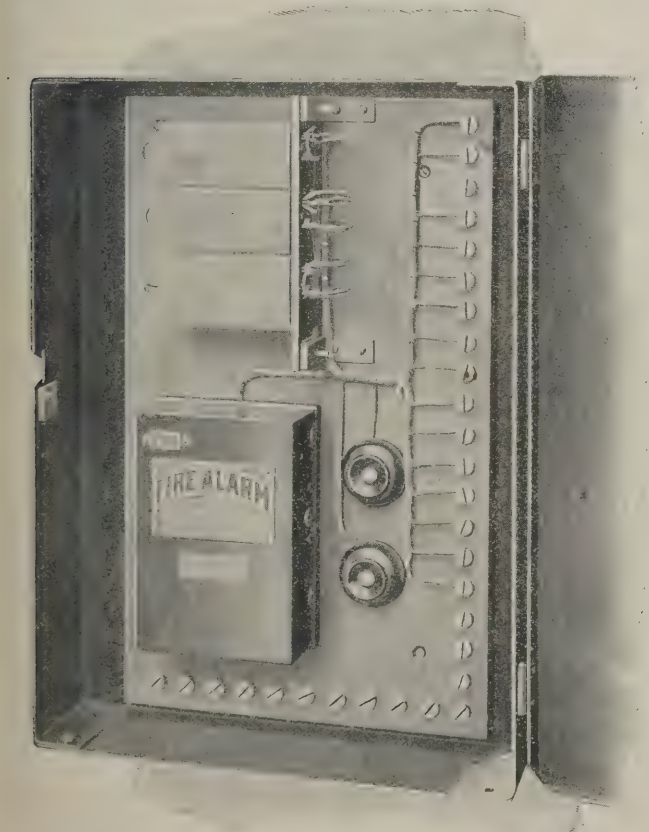


Fig. 2. Single Station Set.

This trouble signal consists of a local trouble bell at the building, and in addition to this local alarm a distinctive signal is transmitted over the telephone line to the operator.

The telephone trouble signal consists of a vibrating electro-magnet which is bridged across the telephone line by either test relay. The trouble alarm cuts off the subscriber's telephone and sends in the trouble signal to the telephone operator, and remains operative until the trouble is remedied. The telephone line battery is used, thus eliminating any chance of its non-operation due to failure of the local battery.



Master Box, and Panel Where More Than One Station is Needed.

Transmission of Fire Alarm While Factory System is in Trouble.

One ground on the building wiring has no effect upon the operation of the fire alarm, but is immediately detected by the trouble signals and at Central office.

A break in any part of the floor circuit does not render the system useless, but simply sends in the trouble signals due to the operation of a test relay, which operation also closes the circuit in such a way as to leave the system in condition to transmit an alarm should a manual station be operated from the circuit in which the break occurred.

The release of the movement in the transmitter box in addition to sending in a fire alarm, automatically cuts off the trouble signal, should it be present and the telephone instrument also when an alarm is being transmitted, thus insuring the non-interfering with the fire

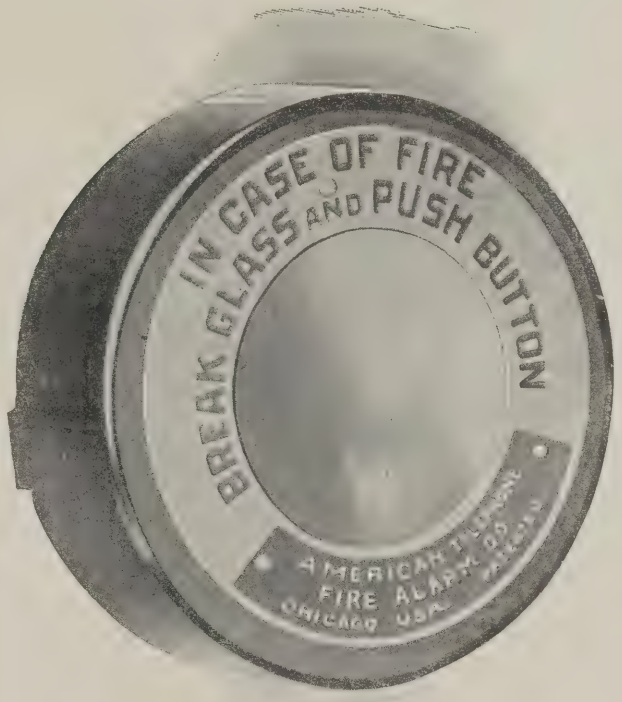


Fig. 4. Push Button Alarm.

alarm due to the subscriber's telephone being in use or a trouble signal being in operation.

Telephone Central Office Arrangements on Manual Telephone Switchboards.

One section of the telephone switchboard used for combination fire call and regular telephone business is equipped with fire plugs. These positions are operated by trained telephone operators. All telephone lines having auxiliary fire alarm system are transposed, being connected to the regular telephone signaling equipment, of the fire call positions. This permits bringing all telephone fire alarm lines to one operator or set of operators, regardless of the subscriber's telephone number or its former position on the switchboard. This is accomplished by means of the wiring on the cross-connecting rack which is a part of the regular equipment of every manual telephone exchange, and by means of which telephone companies distribute the business of the exchange with regard to grouping of lines for different purposes.

The telephone wires are run from the telephone lightning arrester directly to the transmitter box and through the cut-out in the transmitter box to the telephone, conforming with the telephone specification work. In the telephone switchboard fire plugs are installed two to each section of the switchboard comprising three hundred lines. There is a direct talking circuit with signaling apparatus from the chief operator's deck to fire headquarters, in addition to the telephone fire alarm register circuits.

Apparatus at Fire Headquarters.

The apparatus at fire headquarters consists of a standard punching register and a bell, both wired in series with the alarm circuit from the telephone central. No relays are installed at fire headquarters, but the coils of bell and register are connected directly into the fire alarm line, which is under constant current test.

The receiving apparatus for chief operator's desk at telephone central office consists of standard telephone relays and a standard form of punching register controlled by such relays. A tap bell is installed at the chief operator's desk and operates simultaneously with the register.

Automatic Systems.

Where this system is installed in connection with the automatic or so-called Strowger type, the wiring and operation of the shop equipment is the same as described for manual systems.

The connection to fire headquarters from the telephone exchange is made in an entirely different manner.

A certain "level" in one of the switches is set aside for fire alarm service. To this "level" are connected one or more repeaters, a fire alarm trunk to fire headquarters being connected to each repeater. The fire alarm transmitter at the "risk" in addition to the code box number wheel has a second wheel which is designed to send correct series of impulses to step the various selector switches to build a trunk connection to the fire alarm repeater. The further operation of a fire alarm transmitter sends in four rounds of the box, then clears out the entire trunk connection, restoring the suscriber's telephone to service. The entire operation is then repeated, the second call being but a confirmation of the first. Fifteen seconds after the fire alarm transmitter is put in operation, the box number is reported on the register at fire headquarters.

Should the telephone line be in use at the time the fire alarm box is operated, the connection is automatically cleared out, the box taking possession of the telephone line to send in fire alarm call

Magneto Telephone Systems.

For use in connection with magneto telephone systems some additional equipment is provided in the telephone exchange. It may be arranged so that when a fire alarm box is operated the "drop" falls as in the manner of an ordinary telephone call, the further disposition of the call being the same as described for manual common battery systems.

Connection may be made in such a manner that the calls are automatically transmitted to fire headquarters without the assistance of the operator.

For Private Branch Exchange Installations.

Where buildings are equipped with private branch exchange connections, that is, having a small telephone switchboard, the system may be arranged in the same manner as described for manual common battery telephone systems. Instead of installing the interior wiring system, it is entirely feasible to mount the regular single station type fire alarm transmitter in any preferred place, connecting to the nearest telephone line. Connection from the private switchboard can be made to the central office and fire headquarters or to any other place where it is desired to have the fire alarm signals recorded.

In a factory or shop equipped with a private branch exchange where no operator is employed during the night time, connections may be established at the branch exchange so that an alarm being turned in from any fire alarm box would go directly over one of the trunk lines to the telephone central office. This connection also enables the watchman to telephone directly to the telephone central office from any section of the building thus equipped.

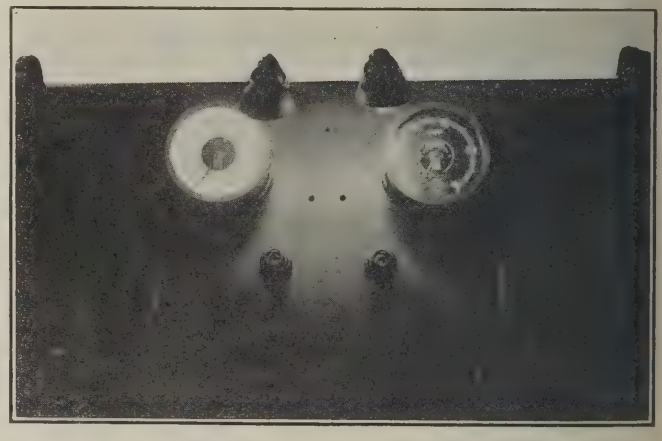
General Considerations.

The use of a telephone circuit for fire alarm service makes possible the individual fire alarm station in every home, store or factory and in the event of a fire will be the means of saving much property by securing prompt assistance. In trying to telephone an alarm, numberless instances could be cited where it was impossible to learn the location on account of the exitement of the person trying to report it. Reliable statistics for the past five years show that in the United States more fire alarms are transmitted by telephone than in any other way.

A NEW DEPARTURE IN SWITCHBOARD METERS.

One of the elementary principles of scientific illumination is that only those parts should be illuminated that are desired to be seen. This principle has been utilized in a uniform line of seven inch dial indicating switchboard meters recently placed on the market by the Westinghouse Electric and Manufacturing Company.

A white mark on a black background is much easier seen than a black mark on a white background, and, therefore, these meters are supplied with black dials, the markings on which are white. Their particular field of application is in installations involving poor natural or



Comparison of Old Style and New Style Meter Faces.

artificial illumination. A white object causes a certain amount of halation which makes the mark on it appear larger. It also tends to blur dark lines on white dials; and, as the eye tends to adjust itself to this condition, a certain amount of eye strain is found to result. Since a lens cannot adjust itself to such varying conditions, the photograph reproduced in Fig. 1 shows the black and white dial meters under identical conditions of illumination, and from which it is an easy matter to determine the relative readability of the two types. Every possible precaution was observed during the taking of the photograph to insure an exact comparison, and the view well illustrates the difference in favor of the black dial. In actual switchboard practice, the pilot light would be equipped with a reflector but the comparative effect would be the same.

So popular has this new feature been since its introduction that a number of large operating companies have ordered the meters on their boards to be so equipped.

SHOP SECTION
EDITED BY
GEO. W. CRAVENS

M. & E. T. Ry. Shop

The repair shops of the M. & E. T. R. R., are located in the town of Marshall, Texas, and are a typical example of the small railroad shops using electric drive throughout. The railroad lies in eastern Texas and serves a cotton and lumber district lying within 18 miles east and 74 miles west of Marshall.

There are two main buildings comprising these shops, both of reinforced concrete, one being a combined machine and blacksmith shop 250 ft. long by 40 ft. wide, and the other the wood working shop 75 ft. long by 25 ft. wide. The machine and blacksmith departments are separated by a wall, the machine shop being 150 ft. long and the blacksmith shop 100 ft. long. Power for operating these shops is supplied by the Arkansas Ice and Coal Co., Marshall, Texas, and comes in over a three phase, 60 cycle, 1100 volt line to three 15 K. W., transformers. These transformers are connected in delta and give 220 volts on the secondaries for use in the shops.

All motors used here are standard Westinghouse, 3-

Fig. 1. Interior of Machine Shop.

phase, 60 cycle, 220 volt induction motors and are equipped with auto-starters and oil-switches with overload release coils. Owing to the operating conditions, no provision has been made for artificial lighting. This is an exceptional case and is worthy of notice, because, railway shops generally want every provision made for getting out work in a hurry regardless of working hours.

Machine Shop.

There are three pits in the locomotive machine shop, one of which is arranged for dropping the wheels, and benches are arranged along the walls as in other shops. The natural lighting is very good, even on cloudy days, so the absence of electric lights causes no delays. All machinery is driven from a single line shaft operated by a 30 H. P. 1740 R. P. M., motor, the equipment being as follows:

1 36" x 14' Schumacher and Boye engine lathe.
1 18" x 10' Schumacher and Boye engine lathe.
1 18" x 10' Hill and Clarke engine lathe.
1 72" Niles-Bement-Pond wheel lathe.
(This lathe is equipped with bracket for motor later).
1 32" standard drill press.
1 12" two wheel emery grinder.
1 24" back geared crank shaper.
1 36" Clevelander planer.
1 ⅜" portable drill, 220 volt, single phase.
Also, a 9½" Westinghouse air pump, steam driven.

Blacksmith Shop.

The blacksmith shop contains four fires and is used for a part of the boiler work. The main line shaft here is driven by a 10 H. P. 1740 R. P. M., motor and drives all of the machine tools, as follows:

1 30" cupola blower (to have separate motor later)
1 2" single head bolt threader.
1 flue welder.
1 combination punch and shear.
1 6" straight rolls.

Also, one 800 lb., steam hammer. Both the hammer here and the air pump in the machine shop receive their steam from an old locomotive boiler which has been set up for this purpose.

Fig. 2. Interior of Blacksmith Shop.

Wood Working Shop.

The wood mill is well ventilated and lighted, the line shaft is driven by a 20 H. P., 1740 R. P. M., motor, and the machinery includes the following wood working tools:

1 Fay and Egan No. 1 rip saw.
1 Fay and Egan No. 58 band saw.
1 No. 114 combination mortiser and boring machine.
1 24" cut-off saw.
1 48" grind-stone.

During the three years these shops have been operating there have been practically no troubles with the electrical equipment, thus adding further proof that electrically operated shops are absolutely dependable. The only things requiring attention have been the renewal of a few contact points in some of the motor starters and the replacing of one lining in a motor bearing. This makes the upkeep per motor pretty near zero.

In conclusion, the writer desires to thank Mr. H. L. Flint, of the Arkansas Ice and Coal Co., for his kindness in supplying the data from which this article was written.

LESSON NO. 13.

Axle Lighting

GOULD TYPE K. and L. EQUIPMENT.

This equipment has many distinctive features which are both unusual and very interesting to the student of railway car lighting. An electrical pole changer is provided which maintains proper polarity of the generator and the output of the generator is regulated by means of a small auxiliary armature placed in the field circuit. This auxiliary generator is mounted right on one end of the generator shaft, so rotates at the same speed as the generator at all times. This armature operating in the generator field circuit in opposition to the voltage developed by the generator, reduces the generator field current to compensate for the rise in generator speed above cutting in speed so that the generator voltage is thus rendered entirely independent of train speed.

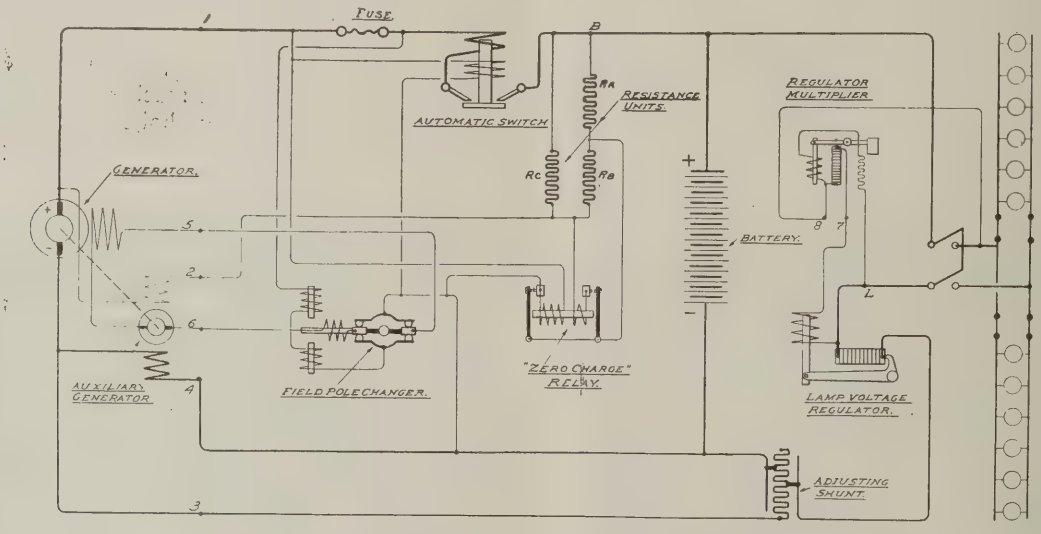


Fig. 62. Wiring Diagram of Gould Type "K and L" Equipment.

Also in the pole changer, we find an entirely new feature in that instead of its being operated mechanically as is usually the case in axle equipment operation, it operates electrically and is controlled in its operation by the same auxiliary armature that controls the generator voltage.

This small auxiliary generator mounted in the generator shaft performs then the triple function of:—

1st. Initially exciting the main generator in the required direction.

2nd. Controlling the action of the pole changer in making the proper field connections.

3rd. Regulating the output of the main generator during speed variations by supplying in the field circuit of the generator, a counter electro-motive-force, varying with the speed changes in proper degree.

Referring to the series of diagrams, Figs. 63 to 68, the operation of the equipment may be followed.

Fig. 63. **Generator at Rest.** When the generator is at rest the automatic switch is open and a small amount of current circulates from the battery through a resistance and energizes the field coils of the auxiliary armature, making connection back to the battery negative through the dead armature wires of the main generator. Since the main generator is at rest, however, there is no voltage developed in its armature and it becomes a simple copper conductor for this low exciting current. The connections of this exciting circuit will be best understood if we simply consider this winding as connected right across the main contacts of the automatic switch. When the switch is open battery will force a small amount of current through this circuit, but when the switch closes, due to the rise in generator voltage equal to battery voltage, the automatic switch short circuits the windings of this small shunt field. Moreover, as the generator voltage is building up it opposes the flow of this current through its armature and gradually reduces the excitation of the auxiliary machine. Or, in other words, as the generator voltage rises to normal value the voltage developed in the auxiliary armature falls off to zero value; so at the cutting-in speed when the automatic switch operates, the generator is operating as a simple shunt machine.

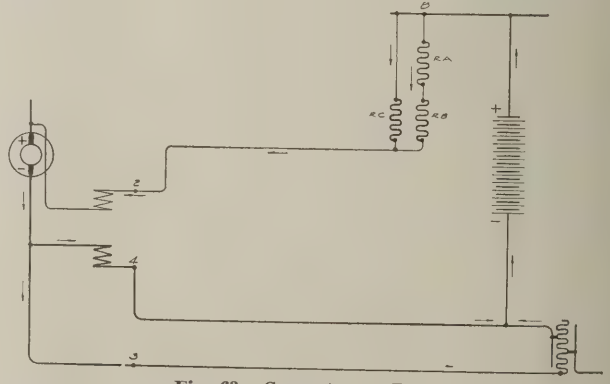


Fig. 63. Generator at Rest.

Fig. 64. **Generator Rotating.** Low speed left hand direction. The shunt field of the auxiliary machine is already excited by the battery, so as soon as the generator begins to revolve, it will set up an electromotive force in the armature of the auxiliary machine which will circulate a mild current through the main field coils

of the generator and also through the center coil of the pole changer. This excitation of the main machine will cause it to build up early and circulate a comparatively strong current through the outer coils of the pole changer. The action of the currents in the two windings of this device causes a movement in a direction to combine the two local circuits into one circuit in which the same direction of current is maintained as was initially set up upon rotation of the armatures. In other words, the pole changer rearranges the connections in such manner that the united voltages of the two armatures in series are impressed across the main field winding when building up.

As ordinarily understood, the pole changer does not actually transpose any connections to cause a reversal of field, but simply establishes the proper connections to maintain the exciting current in the direction initially determined by the direction of rotation of the auxiliary armature. In the true sense, therefore, this auxiliary

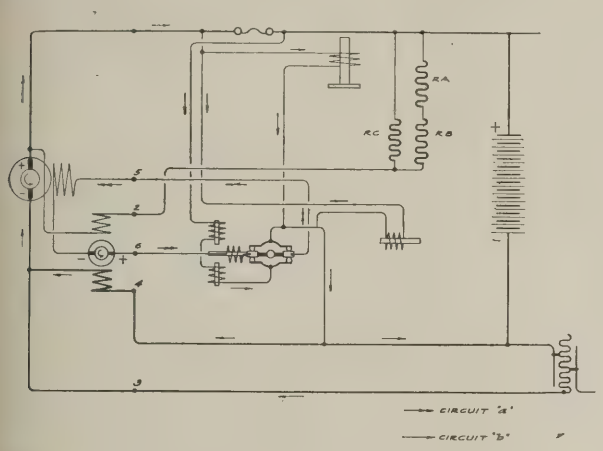


Fig. 64. Generator Rotating at Low Speed, Left Hand Direction.

machine is the actual pole changer. As a matter of fact the pole changer, once operated, will maintain its position whether running or at rest, until the direction of car motion be reversed.

Immediately upon actuation of the pole changer the generator builds up and operates as a true shunt machine, the main armature furnishing the substantial excitation and, upon attainment of sufficient speed and voltage, the automatic switch closes and connects the battery and external circuit across the generator.

Fig. 65. **Generator Operating.** Left hand direction. The field pole changer has now operated and the automatic switch closes as outlined above. As the train speed rises the generator will cause a charging current to flow into the battery, but a certain portion of this current will flow through the heavy winding of the auxiliary ma-

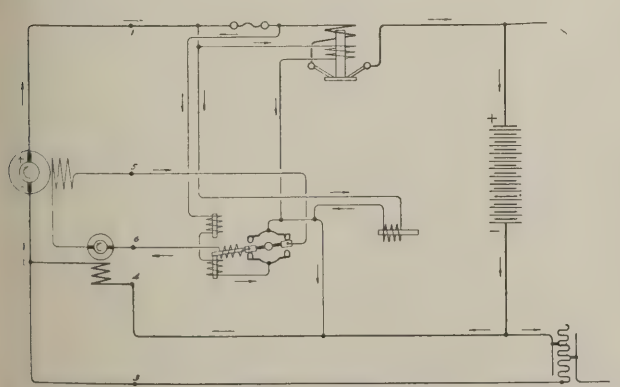


Fig. 65. Generator Operating Left Hand Direction, Automatic Switch Closed and Field Pole Changer Operated.

chine. The magnetism of this current is opposite to that generated by the original exciting current, so the polarity of the auxiliary armature now becomes reversed. This opposes the flow of the main generator field current which passes through the armature of the auxiliary machine and reduces this generator field current slightly.

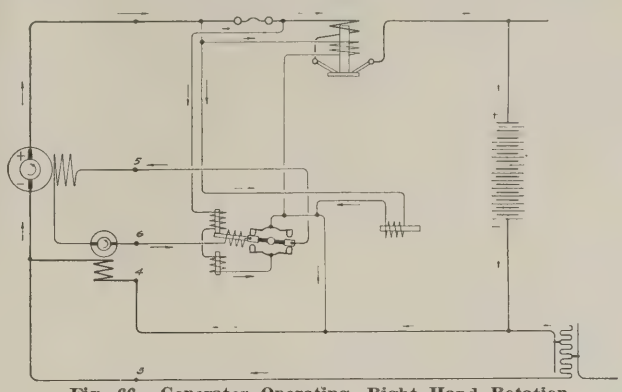


Fig. 66. Generator Operating, Right Hand Rotation.

Continued increase of speed will be followed by increase of current into the battery and increase in bucking voltage of the auxiliary machine, until finally such a value is reached that the magnetising effect of the heavy winding will establish a counter E. M. F. in the auxiliary armature in the correct proportion to compensate for rise in generator speed.

The current will rise to such a value at any speed that the opposing voltage produced by the auxiliary machine in the main field circuit will bring the excitation of the main machine to a value just necessary to generate the output for which the system is adjusted.

Fig. 66. **Generator Operating.** Right hand direction. When the train starts on return trip, the equipment builds up just as explained in the first two paragraphs of this series, except that the magnetism of the center coils will be developed in the reverse direction and this will reverse the connections through the pole changer.

Fig. 67. **Zero Charge Relay Operating.** After the equipment has been on the road for a sufficient length of time for the battery to become fully charged, the charging voltage of the generator will have risen to approximately 85 volts on a 60-volt equipment, 42 volts on a 30-volt equipment, and at this point the storage battery is approximately in a fully charged condition.

The zero charge relay is a coil of fine wire placed

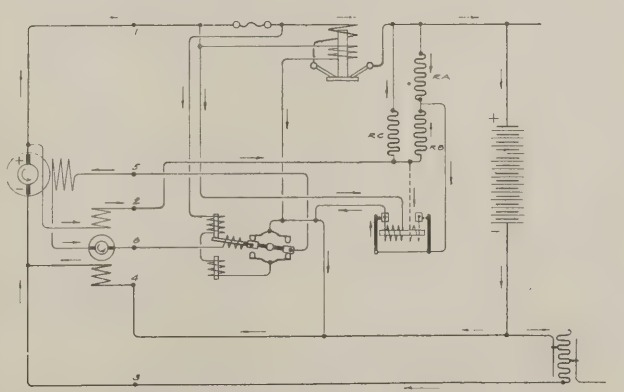


Fig. 67. Zero Charge Relay Closed.

across the generator terminals and so adjusted that it will operate at the above mentioned voltage when the battery becomes charged and re-establishes the circuit through the fine winding of the auxiliary machine field. This current flows in the opposite direction from that when originally exciting the generator, and the magnet-

ism of this field coil combines with that of the main generator current flowing through the heavy coil of the small machine and increases its bucking voltage. This cuts the generator voltage down to such a value that the storage battery simply floats across the line and receives little or no charge.

The regulating function of the battery current through the series coil of the small machine, however, is still retained, and the equipment operates, in every other respect aside from the battery charge, as if normal condition prevailed until the voltage of the generator caused by slowing speed, falls below a certain value, which causes the relay to open and normal conditions of the equipment again prevail until the battery voltage again rises to 85 volts when the "zero charge" relay will again operate.

Adjustment.

The equipment is really a very flexible one in so far as the adjustment of the generator output and battery charging rates are concerned. By a proper manipulation of the adjusting shunts as shown, Fig. 62, the equipment may be made to operate either on a principle of battery current regulation in which the battery is charged entirely independent of the number of lamps in service and the generator output varies with the varying lamp load; or it may be made to operate on a principle of constant

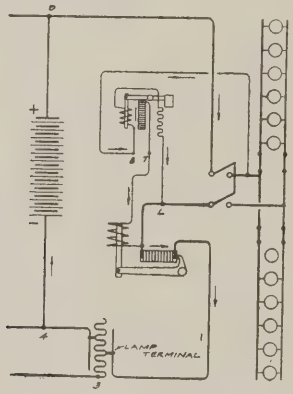


Fig. 68. Circuits Through Lamp Regulator and Multiplier.

current regulation in which the generator output is maintained constant irrespective of lamp load, and, accordingly, the battery charging current varies inversely with the number of lamps in use; or it may be made to operate on a combination of the two types of regulation in any desired ratio, thus providing that the generator load increase somewhat with an increase of lamp load, but not in direct proportion to it, and that the battery current decrease somewhat as the lamp load is increased, but similarly, not in direct proportion to it.

This last adjustment, involving a combination of battery current and constant current regulation, is of real merit in the operation o faxle equipments, for while it retains the good feature of the battery current regulator in providing a moderate charge of the storage battery at all times, it also retains something of the excellent generator load factor experienced in the operation of the constant regulator. That is, the battery current decreases as the lamp current increases and vice versa, thereby providing against an overload of the generator and at the same time providing a substantial generator load at all times.

Lamp Regulator.

The main regulator is of the carbon pile type as has been described in previous lessons. There is a lamp regulator multiplier added which is almost identical in design with that of the main regulator, except that it is smaller in every detail. The object of this is to multiply the variations in voltage across the lamps and make the main regulator very sensitive.

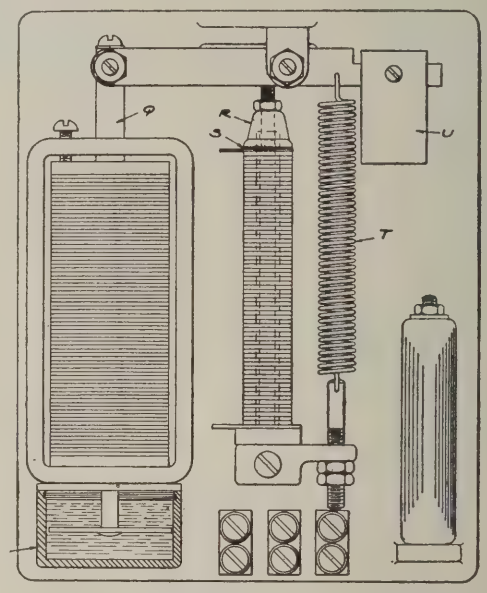


Fig. 69. The Multiplier for Lamp Regulator.

The solenoid of the multiplier is placed directly across the lamp circuit terminals, and its plunger moves in accordance with the fluctuations in lamp voltage. A slight motion of the plunger changes the pressure on a pile of carbon discs, either increasing or decreasing the aggregate resistance of the pile as the lamp voltage goes above or below normal value.

The pile of carbon discs of the multiplier is connected

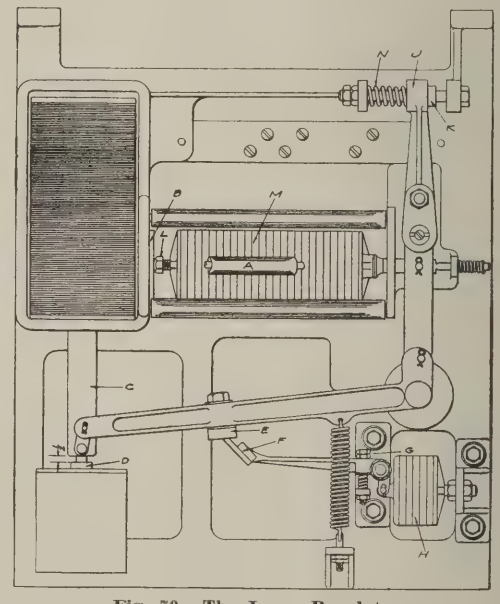


Fig. 70. The Lamp Regulator.

in series with the fine winding of the main lamp regulator, and the resistance of the carbon pile constitutes the major part of the total resistance in this circuit. When the lamp voltage is too high by even a slight amount, this will increase the pressure on the small pile of discs by increasing the magnetic pull on the iron plunger, and in so doing decreases the resistance of the multiplier carbon pile. This decrease in resistance causes the current through the multiplier carbons and fine winding of the main regulator to increase by a comparatively large amount, and this increase in magnetizing current pulls

up the plunger "C" with considerable force, releasing the pressure on the pile of heavy carbon blocks "M" which carry the lamp current. Loosening the pressure on these carbon blocks increases their resistance and cuts down the lamp voltage to a proper amount.

The point of this all is that the multiplier is very sensitive to slight variations in lamp voltage, and causes a comparatively large variation in the carbon pile of the main regulator. In this way a very sensitive regulator is obtained, yet at the same time permits of heavy construction in the lamp regulator itself. When the car comes to a stop the voltage falls slightly and the plunger "C" is allowed to fall down. This makes contact between the points "E" and "F", short circuiting the carbon pile "M" through a very short pile "H", which is of low resistance. This is provided so that there will be little or no resistance in the lamp circuit when standing in stations and battery on discharge.

Head End System

NORTHERN PACIFIC RAILWAY EQUIMPENT.

The management of the Northern Pacific Railway many years ago ruled that there must be storage battery auxiliary on every car of their headend trains operating through to the coast, so a battery of 60 ampere hour capacity has been adopted for this service. Thirty-two cells are mounted on every car and these are so connected on the locker switchboard that under normal operation they are cut off entirely from the train line or lamp circuits. When the headend set is shut down at engine changes or for other causes, the brakeman throws in the battery discharge switch and the battery then lights the night circuit only. The idea of this is obviously to save on battery discharge current.

These batteries are charged during the daytime when the lights are off and when no damage will result from raising the train line voltage to full charging voltage of the battery. When a battery is placed on charge it is necessary to throw in the battery charging switch which connects the storage battery direct to the train line.

Although this system may have certain advantages, providing possibly more reliable operation since it has a storage battery on every car, it would seem that the disadvantages of higher cost of maintenance and the fact that the train man must throw the battery switch before the storage battery current is available, would rather outweight its advantages.

It certainly costs more to maintain four separate batteries of 60 ampere hour capacity than it does to maintain a single battery of 240 ampere hour capacity; yet, the total capacity of the four 60 ampere hour batteries and the one 240 ampere hour battery is the same. Of course, with the Northern Pacific system where only a part of the lights are used when depending on the battery, the total battery capacity required will be only about ½ that necessary when the full number of lamps are used during engine changes, etc. The general practice in this country, however seems to be that there shall be no change in the amount of illumination provided within the car whether under normal conditions with the steam turbine set operating, or whether it be at engine change where the total lamp current is being supplied by the storage battery auxiliary.

(Car Lighting Lessons to be Continued Next Month.)

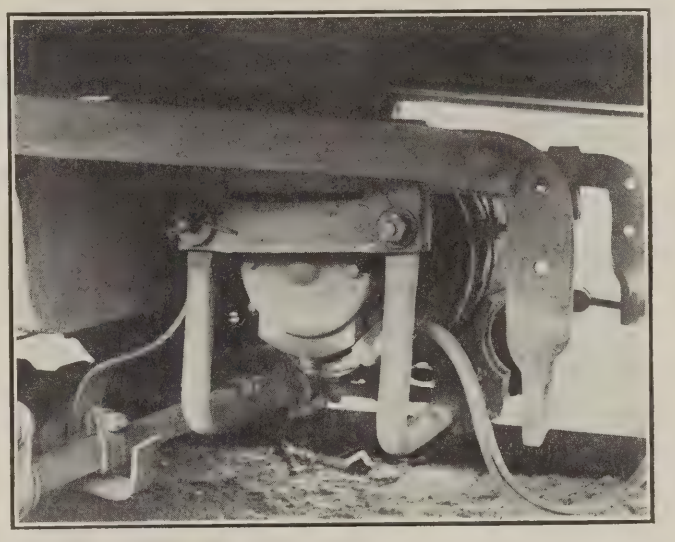
Practical Stunts

We pay for ideas published in this section. ($1.) So send in your practical stunts and special kinks. Never mind about the fine English or diagrams, just a rough pencil sketch with the idea in your own words will do.

New Saddle Iron Yoke.

The spacing bars of a dynamo suspension often become worn, bent or broken so the welded yoke saddle iron as designed by the engineers of the Santa Fe will be of interest. This is shown pretty well in the accompanying illustration. The two saddle irons which are commonly held apart by the spacing rods of an ordinary suspension are solidly welded together at the proper spacing by a 3-inch piece of iron. A hole for a set screw is drilled and threaded on the outer face near the top.

In mounting a generator this double saddle iron is thrown over the side irons and the generator with suspension loops set in place. In lining up the generator, the saddle iron yoke can be driven into place with a hammer and the set screw in each saddle iron clamps this solidly to the suspension side iron. If it becomes necessary to shift the position of these saddle loops, it is only necessary to loosen the set screws and drive it to proper position, when it can be again firmly clamped in place by the screws. S. W. Everett.



Saddle Iron Yoke in Position.

Setting Automatic Switches.

I have had reason on numerous occasions to suspect trouble with the auto-switch, and having no motor to operate the generator found by placing the battery on charge with the use of resistance could get a voltage range of from 33 to 36 volts taken across the battery terminals on the generator regulator panel. Then by disconnecting one lead of the lifting or shunt coil of the automatic switch and connecting this lead to a piece of solid wire (say No. 8) about three ft. long and with this pressing against the battery terminal on the regulator panel, could adjust the automatic switch so as to pick up at proper voltage or near enough to insure the proper operation of the generator. If the lifting coil circuit were open this would be indicated by the absence of any spark on breaking contact at the battery terminal.

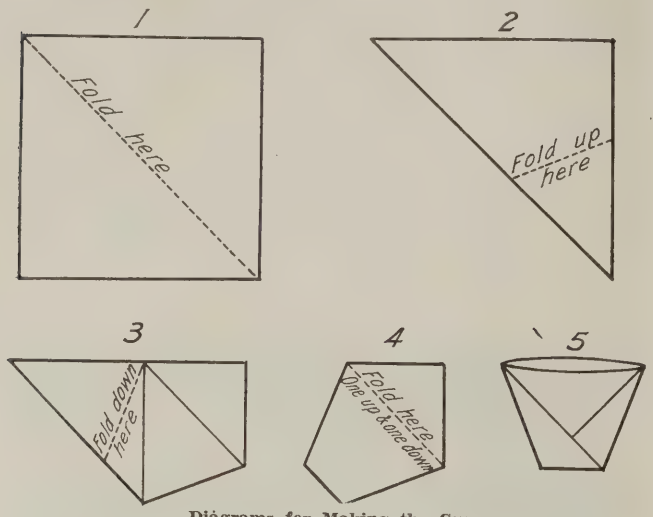
On the Safety panel, as this generator has no exciter connection to the positive side of the battery, it will be necessary to disconnect top lead of lifting coil and touch positive battery terminal. On Bliss and Gould Simplex, as these generators have exciter connection, disconnect lower lead of lifting coil and touch negative battery

terminal. It is advisable to take the battery off charge and test to find if the automatic switch cuts in at less than 32 volts, as in adjusting in this manner it is very easy to set switch to cut in at too low a voltage.

W. B. Hoschke.

A Home-Made Drinking Cup.

With the passing of many State laws abolishing the public drinking cup, the passenger and train men often find themselves with plenty of water but not a drop to drink, because they have no drinking cup.



Diagrams for Making the Cup.

Herewith, however, is a design submitted by Mr. W. L. Bliss by which any ordinary piece of paper, a time card being of about the right size, may be folded so as to make an excellent drinking cup.

Automatic Switch Trouble.

Had some trouble on one of our cars the other day which I believe will be of interest to the rest of the car lighting boys.

The automatic switch plunger and tail rod were seriously burned, so I supplied new plunger and tail rod, but still got a heavy current through the automatic switch with both machine fuse and field fuse out of circuit.

This trouble was found to be caused by two grounds, one on the lower left hand contact of the switch, and the other on the positive battery. The ground on the lower contact of the switch was due to a broken insulating bushing which allowed the screw to make contact on the frame of the switch. The other ground on the positive side of the line was caused by a bare wire in the junction box underneath the car. A. J.

Removable Frame for Steel Battery Boxes.

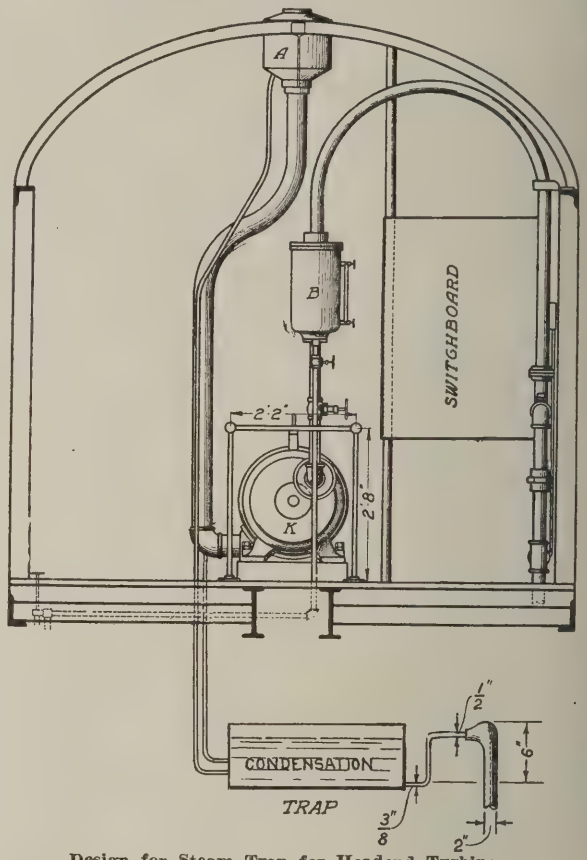
With the new steel battery boxes it is found that grounds and short circuits appear more rapidly than with the old wooden type boxes. In many cases the steel battery boxes have been lined with wood and then painted with a tar paint. In spite of this grounds often develop and cause trouble, and it is very difficult to dry out the wood lining once it becomes soaked with acid.

We have found that a removable latticed floor made up of inch strips a short distance apart can be readily removed, washed and dried or replaced by a new one on short notice where trouble of this nature develops.

C. E. Singer.

Steam Trap for Turbine.

The drip for he exhaust funnel of the turbine is usually carried down in a small pipe through the car floor, and in order to drain off the condensation which might collect in the large exhaust pipe an additional drain pipe is tapped in at the lower elbow, so as to entirely drain the water out of the turbine exhaust line. There is a slight exhausting pressure at this point so a



Design for Steam Trap for Headend Turbine.

hand cock has been usually provided to prevent a continual exhaust of steam through this pipe. When this cock is opened, however, the exhaust steam coming from this tap often is in such quantity as to obscure the view of trainmen in observing signals, so the accompanying design of a condensing trap will be of interest.

Both drip pipes are run directly into this trap, which is simply a 6 in. pipe, 10 or 12 in. long, with a plug at each end through which the inlet drips and the outlet drips are tapped. The outlet pipes of the trap are shown in the accompanying diagram, but in order to prevent the water syphoning over and draining all the water from the trap, this pipe run is enlarged from a 3/8-in. pipe at the start to a 2-in. pipe, which prevents any syphoning.—A. V. Westervelt.

G. E. HAND BOOK ON INCANDESCENT LAMP ILLUMINATION.

A vest pocket hand book, containing much information on incandescent lamp illumination, has just been issued by the General Electric Company. In view of the inability of engineering hand books and text books on illumination to keep pace with the rapid progress which is being made in the electric lamp industry, this convenient little reference book should prove of great value to all interested in the sale or use of lamps. It covers the subjects of photometers, illumination, calculations, reflectors, general information on incandescent lamps, etc.

C. A. LUCKEY JOINS EDISON FORCES.

Mr. C. A. Luckey, well known among car lighting men, has recently joined the forces of the Edison Storage Battery Co., with headquarters at Chicago.

A NEW VESTIBULE LIGHTING UNIT.

The subject of vestibule lighting is one which, in the past, has by no means received the study which it deserves. Adequate vestibule lighting has a most important bearing upon the question of maximum safety to the passenger. Moreover, the attractiveness of the service is not a little influenced by the adequacy with which the coach vestibules are lighted.

In vestibule lighting, the question of exact type of light distribution is one of secondary rather than of primary importance. The four major requirements of this class of service are as follows:

(a) The lamps should be screened from the eye to as great a degree as practicable, so as to minimize the blinding effect produced when the bare lamp filament comes within the normal field of vision.

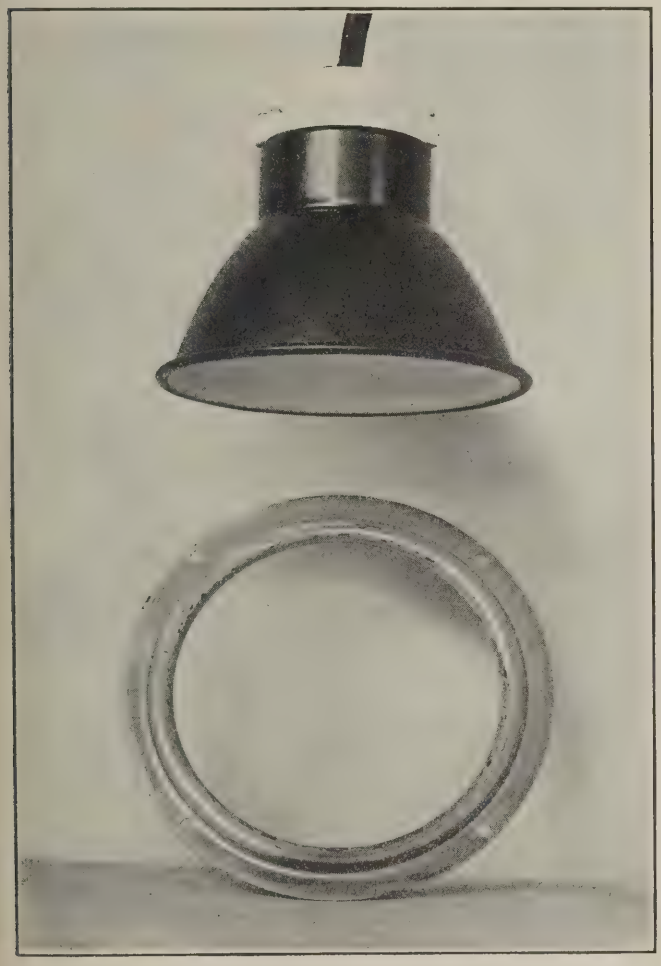


Fig. 1. The Vestibule Unit with Supporting Ring.

(b) The unit should be highly efficient in order to leave as much of the battery capacity as possible available for the more exacting requirements of lighting the inside of the car, without at the same time sacrificing to any essential degree the adequacy of the vestibule lighting.

(c) The satisfactory vestibule unit will be of such a character that it does not rapidly deteriorate in service and that it can be easily restored by cleaning to its full original efficiency.

(d) The unit should have no parts to work loose in service, and should be of such a character as to be unaffected by moisture or even by water.

Among the secondary requirements of vestibule lighting, the following may be regarded as most important:

(a) The unit should emit as much light as possible between 0° and 50°, measured from the nadir. In order to reduce glare effect, it should emit as little light as possible above the angle of 50°.

(b) The unit should be as small as compatible with the foregoing requirements in order both to avoid the

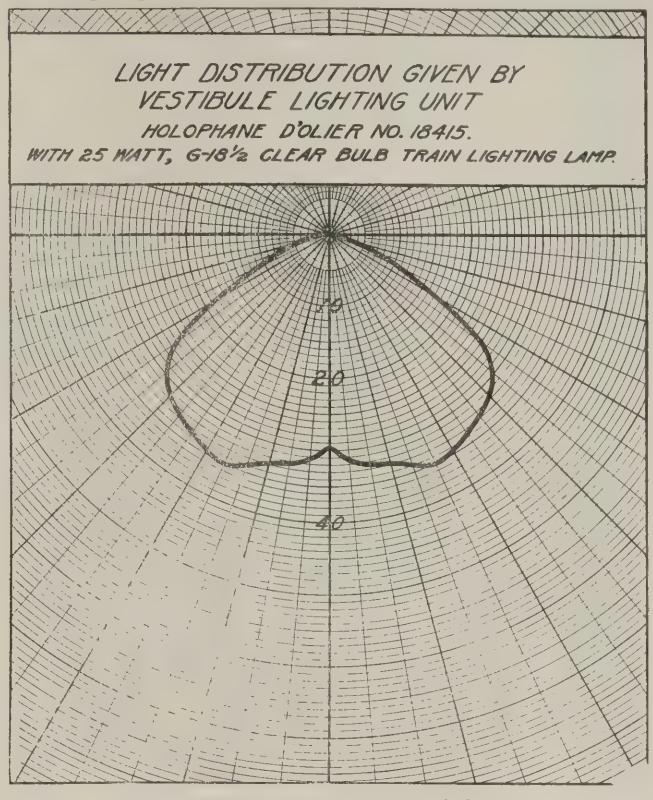


Fig. 2. Distribution Curve of Vestibule Unit.

bad appearance presented by an unduly large unit, and to insure adequate screening of the lamp without prohibitive over-all height of the unit.

All the above requirements seem to have been met to an admirable degree by the unit shown in the illustration. The unit is of a deep bowl type, thus insuring the first requirement expressed above (major requirement a). Furthermore, the lamp sets sufficiently far back into the reflector portion of the unit so as to meet minor requirement a. The unit is of porcelain enameled metal, the porcelain enamel being of a very high grade, thus insuring an efficient unit, easily cleaned, and restored by cleaning to its initial efficiency. A water-proof receptacle is employed and there are no parts which can possibly work loose due to the vibration of service. The reflector is of small size (approximately 5¼" in diameter, the dimension of the vestibule reflector usually employed at present in Pullman car lighting), thus insuring a neat appearance in the installation.

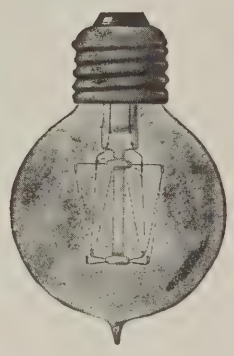
The above unit is designed to be set up into the head-lining of the vestibule deck, preferably one unit being employed on either side over the steps. The unit is held in position by a separate supporting ring. This supporting ring is of steel, and is covered with a coat of paint to keep same from rusting. It is intended that after installation this ring shall be given a second coat of paint of the same color as the vestibule head-lining.

It is believed that the above type of unit will have a large field of usefulness, as it has been developed only after a very thorough engineering and practical study of the requirements of the service.

The above vestibule lighting unit is one of the large number of special car lighting products which have been placed on the market by the Holophane Works of General Electric Company. It is sold by the above Company under the catalogue number No. 18415, which number includes the unit complete with supporting ring.

The Five Essentials

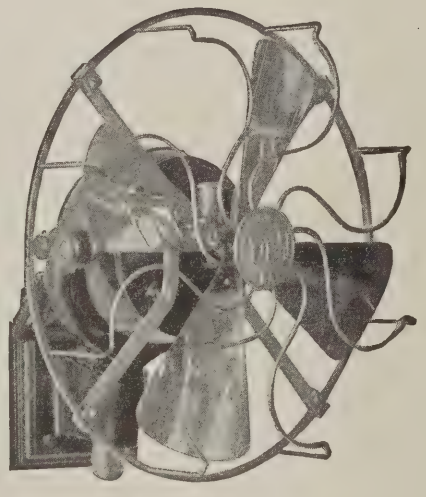
Columbia Mazda Lamps



Drawn Wire Filaments

The mechanical strength of the new Columbia Mazda Lamp has added greatly to its life. In addition it has increased electrical efficiency. We carry an immense stock of low voltage lamps for train lighting service as well as the standard sizes and styles of lamps for ordinary voltages.

The Standard for Train Lighting



Diehl Car Fans
FOR
Railway Car Service

They are the best. When the manufacturers could no longer improve the motor they improved the base. These bases are of artistic design and may be permanently mounted in the cars. The Fan is easily and quickly removed without disturbing its base. No marring of woodwork—no loss of time.

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Demand on all your orders QUALITY
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OKONITE
TRADE MARK.

Standard of All Rubber Insulations

Okonite insulation with its toughness, elasticity and high electrical resistance is always placed concentrically around the conductor. The result is a product absolutely dependable.

Wire installed in railway cars should be the best. *Okonite* is made in one grade only—THE BEST.

D. & W. Fuses

The Standard by Which All Enclosed Fuses Are Judged

Construction of link used in fuse in operating under severe conditions.

D. & W. Fuses are scientifically designed with maximum service and a resultant minimum volume of metal for a given current value. This enables fuses of reasonable dimensions to meet abnormal conditions of overload. The fibre tubes are exceptionally strong. They are manufactured with steel reinforcing rings when necessary.

Specify D. & W. Fuses and secure the protection you need.

and SERVICE—then write us. We are largest stock of electrical supplies East specialty. If you have *not* our big instruct- asking. Write for it on your letterhead.

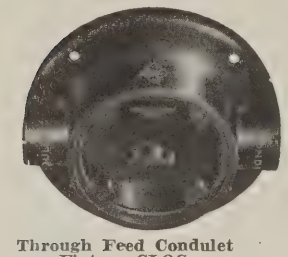
ric Company

of Service CHICAGO, ILL.

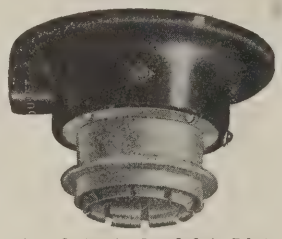
LAMP OUTLETS FOR MAIL, BAGGAGE AND EXPRESS CARS.

Specially designed conduit fittings for railway cars are still such a novelty that new patterns are of active interest to railway electricians and car builders. Below we illustrate and describe a few of the new railway condulets recently placed on the market by the Crouse-Hinds Company. These particular designs are for lamp and fixture outlets in mail, baggage and express cars, where the conduit is exposed.

Types CLO and CLOC condulets, dead end and through feed, respectively, are intended for center ceiling lights, and take round base fittings, notably Safety Car Heating and Lighting Co. combination shade and socket holder No. 8294 and, where a metal shade is desired, the Crouse-Hinds receptacle and shade holder equipment, consisting of shade and receptacle holder



Through Feed Condulet Fixture CLOC.



Dead End Condulet Fixture CLO.

SRH 2, receptacle C 337 and shade SH 25. The inside diameter of each condulet is 3⅝ inches and the inside depth is 1⅝ inches. The depth permits a special composition terminal block (CF 101) to be mounted on two posts in the condulet and leaves ample space for slack in leads to the fitting and for the passage, under the terminal block, of wires of another circuit.

Many railroads use the terminal block, as it elimin-

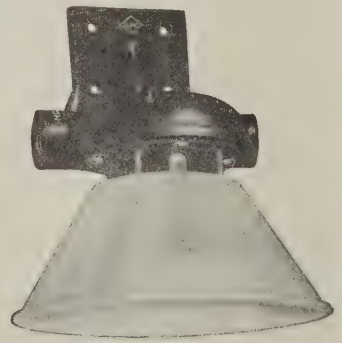
Terminal Block.

Through Feed Condulet Fixture DOBC.

ates the necessity of soldering joints and thus makes it an easy job to remove the fitting for refinishing.

Types LOB and LOBC condulets differ from types CLO and CLOC, respectively, in only one way. Each of the first has four cast ears, pierced for fastening

Through Feed Deck Sill Outlet.



Deck Sill Fixture with Reflector.

screws, projecting from the side that goes against the surface wired over, instead of the continuous flange that gives a more attractive appearance to types CLO and CLOC. Thus the fittings that are suitable for the latter two types are equally serviceable on types LOB and LOBC.

These four types of condulets make excellent water-tight junction boxes for both inside and outside work, when used in conjunction with the special cast cover and gasket made for them.

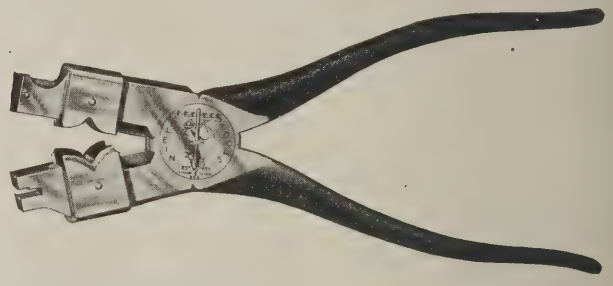
Types BLMA, BLMB and BLMC condulets are, in the order named, left, right and through feed deck sill outlets for round base fittings—the same as fit types CLO, CLOC, LOB and LOBC condulets.

Condulets of the BLM series, however, are too shallow to take the terminal block. Their design permits these condulets to fit over the heads of rivets in steel cars, and the conduit to enter the hubs without being bent away from the car finish.

The other types of condulets in this railway line include designs to meet practically every outlet requirement of the railway field. All are illustrated, listed and fully described in Condulet Bulletin No. 101, which, we are informed, will be mailed free by the Crouse-Hinds Company to all who request it.

WIRE SKINNING PLIERS.

A new tool has just been placed on the market by Mathias Klein & Son, Chicago, which will be of special interest to all railway electricians.



It will be seen from the accompanying illustration that there are knives on both jaws for cutting the insulation while another knife splits the insulation lengthwise of the wire. The end of the jaws is well cross-hatched so as to provide a good gripping service for pulling off insulation. A sharp knife surface is also provided on the upper jaw as shown for scraping the wire if necessary and there is a slot with two different gages provided for bending loops in the ends of wire. The ordinary wire cutting jaws of common pliers are also provided back in the throat of the pliers.

At the present time these special pliers are manufactured only in the size for use with No. 14 wire, but they will be found to be of special service where any amount of cutting and splicing of this size wire is necessary.

GREATEST EFFICIENCY IN REFLECTION OF LIGHT

This is the title of an industrial bulletin recently issued by the National X-Ray Reflector Co., Chicago, which shows the application of their mirrored reflectors in industrial service. Copy of this bulletin will be sent upon request to the National X-Ray Reflector Co., Chicago, Ills.

DEVELOPMENTS IN THOMPSON ELECTRIC CO.

The Thompson Electric Company of Cleveland, Ohio, has increased its capitalization from $10,000 to $50,000 to provide for the increased business which this Company is doing.

Mr. A. J. Thompson, who is President of the Company, is already well known in this trade. Mr. Charles E. Pope, Secretary and Treasurer of the Company, was formerly Mechanical Engineer with The National Malleable Castings Co. of Cleveland, and he will add strength to the organization.

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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Postal Car Illumination.

The railway postal car undoubtedly presents one of the most difficult problems for proper illumination that is to be found in any branch of the art today. The close visual and rapid work which the mail clerks are called up to do continuously requires that a most effective system of illumination be installed. On the other hand, the peculiar construction of the postal car with its partitions and projecting overhead boxes militate against the most satisfactory operation of any lighting system. Up to recently there was very little data available either as to amount of illumination required or as to the relative merits of various arrangements of different types of reflectors to produce this illumination. A much similar situation exists in other classes of railway cars, but the recent standardization of U. S. postal cars by the government railway mail service has made the postal car an especially favorable subject for a thorough investigation along this line.

The Electrical Department of the Baltimore and Ohio Railroad have just completed a most comprehensive series of tests and investigation of this subject, as published in another part of this issue. These tests covered a period of several months and involved the services of not only a considerable number of the B. & O. staff, but numerous illuminating experts of several reflector, fixture and lamp manufacturing companies as well. This is without doubt the most comprehensive investigation of an illumination subject ever conducted by any railroad, and the fact that they refer to a standard postal car, the construction of which will hereafter be the same on all railroads, makes these tests of particular value, in fact, of vital importance to the electrical department of every railroad in the country.

During the course of these tests practically all of the various commercial types of reflectors available were tested; so the results of these tests as published at this time contain much information of interest aside from their specific application to railway mail car service, in that they afford a fairly good comparison of the various types of reflectors on the market today.

For the thoroughness with which these tests have been conducted along broad engineering lines, in which neither time, trouble nor expense has been spared, and for their liberal minded policy in subsequently making public such valuable information, the management of the Baltimore and Ohio Railroad and the various manufacturers assisting deserve the highest commendation and praise.

The Postal Car Layouts.

As supplementing the information obtained in these tests and in reducing this information to a practical application, the series of layouts for the various types of postal cars as published in this issue which were designed by Mr. A. J. Sweet, who was actively associated with this work, will be found of special interest and value.

We published in last month's issue a set of layouts for 60 ft. and compartment postal cars and these are all re-published at this time in order to properly co-ordinate them with the other information now available. These layouts are based strictly upon the information obtained in these tests, and as they have been designed by one of the foremost illuminating experts in the country, their accuracy and authority cannot be questioned.

Portable Electric Tools.

For small work there is probably no better method than to take the work to the tool, but there is a line beyond which it will pay much better to take the tool to the work. And this applies not merely to such tools as electric and pneumatic drills and hammers, but also to grinders, planers, slotters, large drills and tools of that class.

The increasing use of iron floors in machine shops has helped considerably to bring this about. In fact, such floors or their equivalent are necessary to insure proper alignment of tools and work, and unless such alignment is obtained it would be much better to go to the expense of moving the heavy work to the tools. With iron floors the work can be bolted down true to the floor, and the floor then becomes a large face plate upon which properly prepared tools can be set for working on the parts to be finished.

This practice has been developed to the largest extent by makers of electrical machinery and steam engines, but has much good in it which is worthy of very careful consideration by railroad shop engineers. One application would be to the slotting and drilling of side-frames for locomotives, moderate sized vertical planers and slotters and universal drills being now available for this purpose. These have electric motors and controllers mounted on them, with long flexible cables and attaching plugs ready for connecting to convenient sources of supply about the shops.

Small tools, such as electric drills, magnetic hammers, electric grinders and riveters, reamers, arc cutting and welding electrodes, heaters and numerous other devices, have been developed for this purpose and could and should be adopted to a much greater extent than heretofore. We sincerely hope that more of the progressive men in the shops will take this matter in hand and give it a thorough trial, and report on their experiences.

Reversing Motors.

There is nothing new in the general idea of using reversible motors for driving machinery, nor is the reversing motor itself very new. But there are apparently "periods of fashion" in the mechanical and electrical fields, seasons when some old customs are revived and made over and used as though they were new.

Fortunately, however, progress in the electrical industry is very rapid, so, when some old idea is revived and "re-made," in the light of present day knowledge and experience, it becomes to all intents and purposes a new proposition. The present revival of reversing motors and their use in driving planers, slotters and other reversing tools is a good example of this, and in view of the rapid increase in the number of applications we feel it is worthy of comment.

Take for instance the matter of reversing motors for planers. There is no doubt that the reduction in mechanical attachments alone, such as countershaft, pulleys, hangers and shifting levers, should cause such a feeling of relief to the maintenance department as to lengthen their lives. But, there is a much more important phase of the matter to consider, and that is the economical—the effect on cost and quantity of production.

Present day machine shop practice accepts a return speed of about 3 times the cutting speed as good for planers, hence any reduction of time spent in cutting will be a larger per cent of the total than a corresponding saving in the returning time. For instance, if the cutting speed in a given case is 25 ft. per minute and the return speed 85 ft., an increase of 10 ft. in the cutting speed (with same return speed) will show a net gain of approximately 20 per cent in total time per cycle. On the other hand, an increase of 10 ft. in the return speed (with same cutting speed) will give a net gain of about 3 per cent in total time, for the same conditions.

Another advantage arising from the use of motors lies in the reduced power consumption. It is now well known that the condition of the belts, weight and speed of pulleys and their fly-wheel effect, etc., all show in the power bill as well as in production. With direct-connected, adjustable speed, reversing motors the speed is practically constant at all conditions of load, and the maximum cutting speed can be adopted and maintained independent of ordinary variations in hardness of the metal worked on.

The same advantages apply in varying degrees to the use of reversing motors with slotters, shapers, key seaters and other tools requiring a reversal of movement, and also to lathes, boring mills, etc., when a cut of less than a complete revolution is to be made. So, in order to get this matter before our readers in satisfactory shape we will have an article on reversing motors in our next issue. Such motors are made by several manufacturers and reference will be made to actual installations in the forthcoming article.

Association News

COMMITTEE ON DATA AND INFORMATION. QUESTION BOX.

At the 1912 Annual Convention of the Association it was decided that the Committee on Data and Information should conduct a "Question Box" for the purpose of supplying information to such members of the Association as may care to ask questions which come within the field of the activities of this Association.

Arrangements have been made by this committee to have this question box appear regularly in the RAILWAY ELECTRICAL ENGINEER in the hope that any one reading these questions and being able to answer them would do so, in order that every one could get the benefit therefrom.

In this issue there appear the only questions received up to date, and we hope that enough interest will be excited to result in having answers to all of them sent in before the end of the month.

Each month the new questions will be followed by the answers to the questions submitted the previous month, this appearing each time under the general heading of Association News in order that those interested will always know where to find them.

Questions for March.

No. 1. How many railroads furnish rubber gloves, aprons and boots to battery men in the yards?
F. E. H.

No. 2. What is the best method of removing an axle pulley from an axle?

No. 3. Is there any standard for the size and number of wires per coil in an axle light generator armature? G. C. R.

The Committee also desires all those who have ideas to make suggestions as to what kind of information or data will be of the greatest value to the Association members.

Send your answers to these questions to Mr. C. R. Gilman, care C. M. & St. P. R. R., West Milwaukee Shops, Milwaukee, Wis.

Extensions to New Haven Single-Phase System.

The recent decision to electrify the division between Boston and Providence by the N. Y., N. H. & H. R. R. will add about 200 miles of track electrification. The proposed territory being a four-track route, inclusive of yards and sidings. The engineering specifications for the electrification of the Boston Metropolitan district, comprising over 400 miles, is based upon single-phase operation.

This will make four sections in progress and in addition to the original electrification will bring the total electrified track mileage up to 750 miles. Originally there were 114 miles electrified with 41 locomotives in operation, while at present there are 151.

The power house capacity was 21,000 h.p. in 1907 and is 45,000 h.p. at present and the electric locomotive mileage has increased from one and one-half millions to five and one-half millions of miles.

The combined horse-power of electric locomotives now in operation is nearly 130,000 h.p.

Postal Car Illumination

A Report of the Extensive Research Conducted Under the Auspices of the Baltimore & Ohio R. R.

For the purpose of obtaining more adequate data on the subject of postal car illumination, the Baltimore & Ohio Railroad, through its Electrical Department, has just completed an extensive series of tests and investigation of the subject covering a period of several months. The research was made last fall in Washington, D. C., on one of the latest type of 60-foot steel postal cars in use on the Baltimore & Ohio Lines. In conducting the tests the assistance of illuminating experts of the leading reflector, car lighting fixture and incandescent lamp manufacturers was obtained, and in order to insure the greatest accuracy of test results the co-operation of the National Bureau of Standards was extended in calibrating the instruments, rating the lamps used, and making photometric curves of all the light units tested.

The character of the visual work performed in a railway postal car requires a high quality of illumination, and the long hours during which artificial illumination is required make the problem of furnishing a reliable and economical supply of light a difficult one.

That the results of the investigation might be of general value, the tests were carried out on a broad engineering basis, covering all practicable methods of car illumination available at the present state of the art. However, the investigation was confined solely to the question of providing proper and adequate illumination.

This report covers an investigation of postal car illumination. The investigation had for its particular objects the determination of—

1. Location of light units.
2. Best type of reflector.—All types of reflectors at present on the market were investigated and judged from the standpoint of (a) the degree to which the character of the illumination produced by them permitted of easy and comfortable visual work, (b) relative efficiencies, (c) non-production of objectionable shadows, (d) infrequency of cleaning required and ease of cleaning, (e) non-liability to breakage.
3. Minimum intensities of illumination required in various parts of the car.
4. Relative suitability of electricity and Pintsch gas, judged from the character of illumination produced.
5. Proper size and spacing of electric incandescent lamps and gas lamps.
6. Feasibility of indirect lighting, both by electricity and Pintsch gas.
7. Loss of illumination under present reflector cleaning practice.

As a result, partly of the recent standardization of the construction of U. S. postal cars and partly of the completeness with which the investigation covered all phases of the subject, the conclusions derived from this investigation should apply not merely to the practice of the Baltimore & Ohio Railroad but with equal force to the practice of all American railroads.

CONCLUSIONS.

Causes of Present Unsatisfactory Illumination.

General: The investigation showed that unsatisfactory conditions of postal car lighting in the past, not arising from failure of the generating or gas supply system, have been due to improper arrangement of the light units, to unsatisfactory types of reflectors, or to poor maintenance, and not, in general, to insufficient amount of light initially provided.

Location of Light Units.

1. The architecture of the postal car definitely and beyond question pre-determines the correct location of the light units. Under the new government specifications of postal car construction, these locations are as follows: For body of car, on center line of car at a height of 7 feet 6 inches from the floor, measured to center of lamp filament or gas mantle; for letter case, 20 inches in front of face of case, at a height of 7 feet 6 inches from the floor.

Letter Case.

Adequate illumination at the letter case can be provided for only by separate and correctly located light units. Due to the fact that their light is shaded by the postal clerk at work, or by the letter case itself, the light units for illuminating the body of the car cannot correctly be considered as contributing to the illumination at the letter case.

Avoidance of Shadows.

2c. The investigation showed that shadows depend almost wholly upon the location of the light units, and only to an immaterial degree upon the character of the reflector, shade or globe. The only exception to this generalization is that of the indirect lighting system, which casts no shadows. The locations specified above as correct are such as to minimize to the greatest possible degree the objectionable nature of such shadows as are cast.

Best Types of Reflectors.

2. The following table presents the order of excellence of the various types of reflectors, as measured on the four bases of (a) effect of resultant illumination upon the eye, (b) relative efficiencies, (c) cleaning considerations, and (d) liability to breakage:

Effect on Eye	Efficiency	Cleaning Considerations	Liability to breakage
Indirect System.	Mirrored Glass.	Porcelain enameled metal.	Porcelain enameled metal.
Corona globe satin finish, bottom.	Prismatic clear.	Medium density opal, glazed.	Aluminized metal.
Medium density opal, depolished.	Heavy density opal.	Heavy density opal.	Indirect system.
Aluminumized metal.	Aluminumized metal.	Mirrored glass.	Prismatic clear.
Prismatic satin finish.	Medium density, opal, glazed.	Aluminumized metal.	Prismatic satin finish.
Medium density opal, glazed.	Medium density, opal, depolished.	Medium density opal, depolished.	Heavy density opal.
Prismatic clear.	Porcelain enameled metal.	Prismatic clear.	Medium density opal, glazed.
Heavy density opal.	Prismatic satin finish.	Prismatic satin finish.	Medium density, opal, depolished.
Porcelain enameled metal.	Corona globe satin finish bottom.	Corona globe satin finish bottom.	Corona globe satin finish bottom.
Mirrored glass.	Indirect system.	Indirect system.	Mirrored glass.

The four bases above given are not all of equal weight in determining the relative suitability for postal service of the different types of reflectors. After considering the question of relative weighting of the above four qualities from several points of view, the following compromise basis was adopted: Out of a total of 100 points, an importance represented by the figures in the following table was assigned to each of the four qualities under consideration:

Effect on eye	44
Efficiency	30
Cleaning	18
Breakage	8

Assigning the above values of relative importance to the four reflector qualities chiefly to be taken into account, the relative suitability of the various types of reflectors for postal car lighting is such as is given in the following table. Reflectors are given in their order of excellence:

Class of Reflector	Reflector.	Fig. No.
Aluminumized metal.	Holophane D'Olier No. 18460 body of car or the equivalent.	6
	Holophane D'Olier No. 18470 at letter case or the equivalent.	7
Heavy density opal.	Holophane No. 18626 redesigned, or its equivalent.	3
Medium density opal glazed reflecting surface.	Phoenix CL-50, or its equivalent.	2
Porcelain enameled metal.	Holophane D'Olier 18461, or its equivalent.	11
Medium density opal depolished reflecting surface.	Macbeth-Evans Alada No. SF-1623, or its equivalent.	1
Indirect lighting enameled reflector for gas lighting.	Experimental enameled reflector.	
Mirrored glass.	X-Ray 555, or its equivalent.	8
Prismatic clear.	Holophane No. 18226, or its equivalent	5
Prismatic satin finish.	Holophane 18226-SF, or its equivalent.	3
Reflecting and diffusing globe.	Safety Corona No. 8026, or its equivalent	13

While certain of the above reflectors were tested with electric lighting and others with gas lighting, the results are not affected by the type of illuminant used, as the study is confined entirely to reflector quality.

Quality of Illumination Relative to Eye.

Extensive tests to determine the amount of illumination required for comfortable reading indicated that there was an appreciable difference in the character of the illumination given by different types of equip-

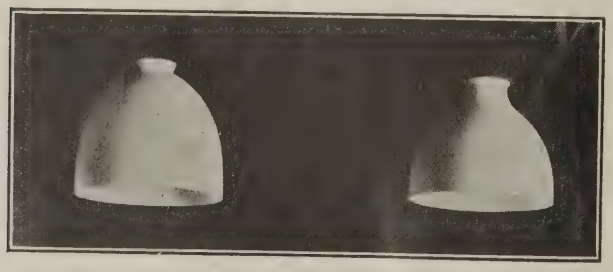


Fig. 1. Macbeth-Evans No. SF-1623. Macbeth-Evans No. SF-1624.

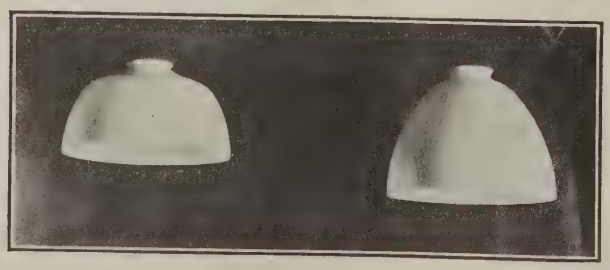


Fig. 2. Phoenix No. 10456. Phoenix No. CL-50.

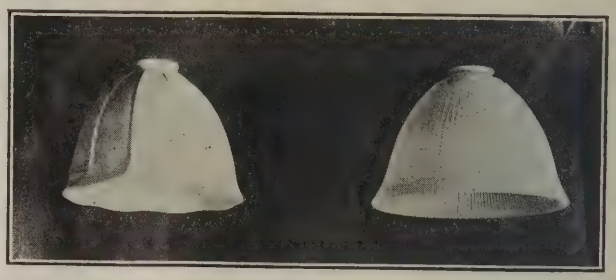


Fig. 3. Holophane No. 18626. Holophane No. 18226-SF.

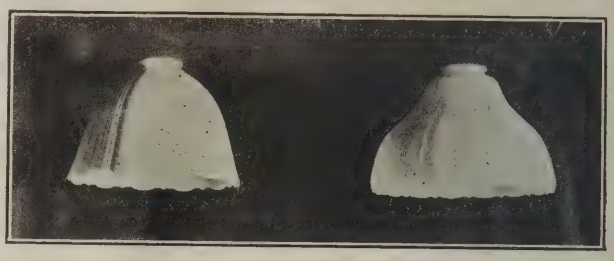


Fig. 4. Opalux No. 123. Macbeth-Evans No. 3429.

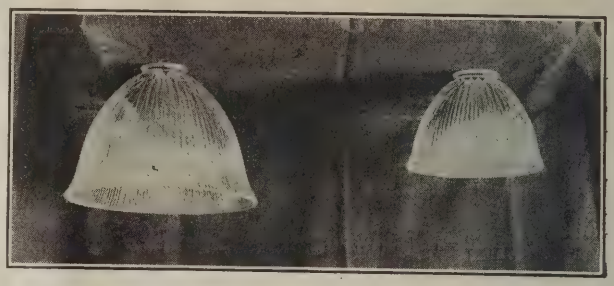


Fig. 5. Holophane No. 18226. Holophane No. 18221.

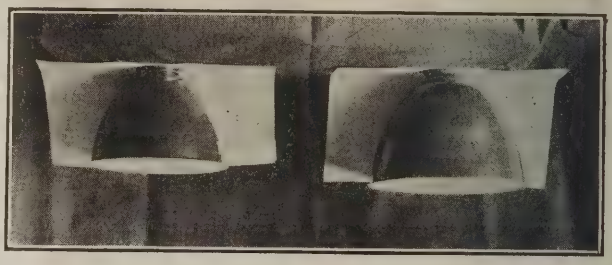


Fig. 6. Holophane D'Olier No. 18440. Holophane D Olier No. 18460.

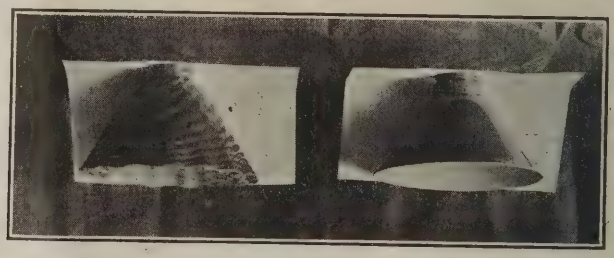


Fig. 7. X-Ray No. 696. Holophane D'Olier No. 18470.

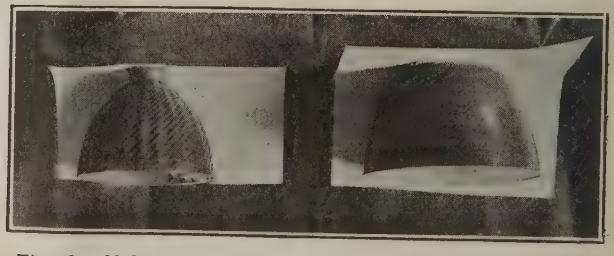


Fig. 8. X-Ray No. 555. Holophane D'Olier No. 18410.

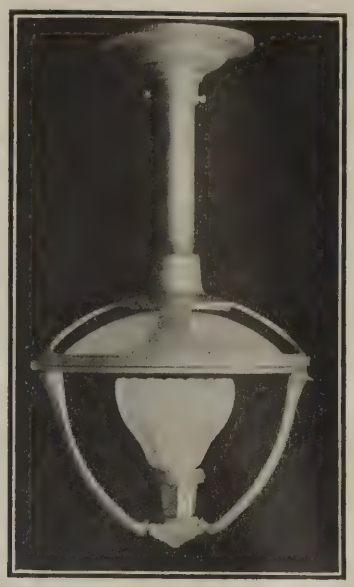


Fig. 9. Adams & Westlake No. 15090-15070.

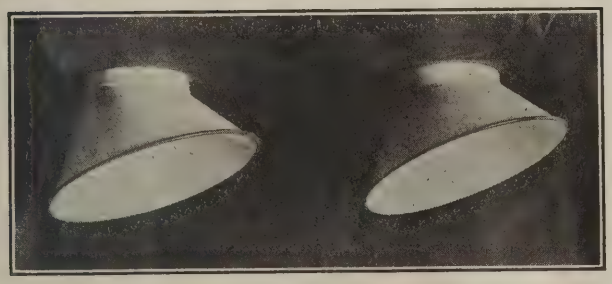


Fig. 10. Holophane D'Olier No. 18479. Safety No. 8409.

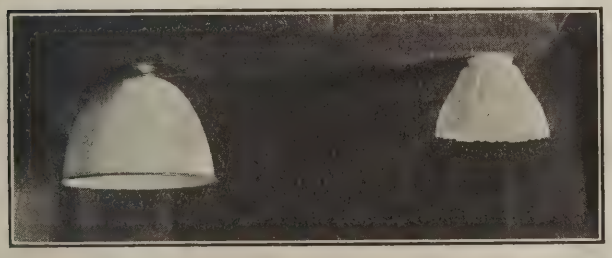


Fig. 11. Holophane D'Olier No. 18461. Macbeth-Evans No. 2619.

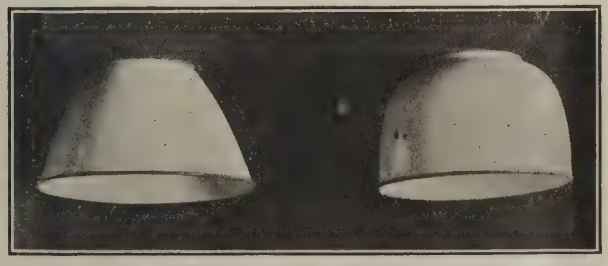


Fig. 12. Holophane D'Olier No. 18417. Safety No. 8565.

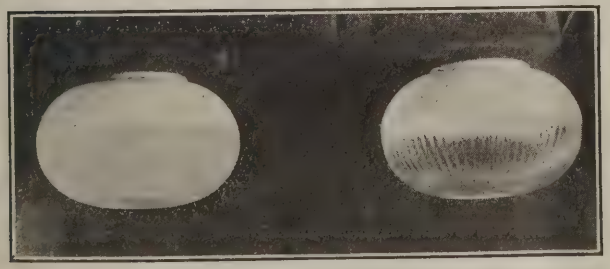


Fig. 13. Safety No. 8026. Safety No. 3425.

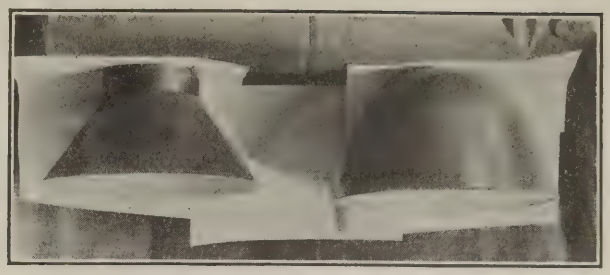


Fig. 14. Holophane D'Olier No. 18490. Holophane D'Olier No. 18418.

ment. Certain types of equipment gave an illumination of such character as to leave the eye in a less satisfactory condition for vision, thus requiring an increased intensity of illumination for adequate vision. For practical purposes, all equipment tested can be divided into three classes relative to the character of the illumination produced. These three classes and the approximate amount of illumination required under each are shown in the following table, the illumination required by the third class being taken as 100 per cent. The test method was not sufficiently sensitive to determine the exact percentage relations, but the figures given may safely be taken as approximately correct:

First Class.	Second Class.	Third Class.
50% Illumination required.	80% Illumination required.	100% Illumination required.
Indirect lighting.	Diffusing globes, all classes. Aluminumized metal reflectors. Opal reflectors, all classes except heavy density with glazed reflecting surface. Prismatic, clear and satin finish reflectors.	Mirrored glass reflectors. Porcelain enameled reflectors. Heavy density opal reflectors with glazed reflecting finish.

Required Intensities.

3. Average results obtained from a test crew of ten, five of whom were members of the Railway Mail Service, showed that 2.25 foot candles was approximately the minimum satisfactory intensity for long continued close visual work under illumination derived from the equipment listed above in class two. On the same basis, 3.5 foot candles was determined to be ample. In other words, the illumination in service should never fall below 2.25 foot candles intensity at any point where close visual work is to be done, and need never be raised higher than 3.5 foot candles in order to provide sufficiently adequate service. It was estimated by different observers, including responsible representatives of the Railway Mail Service, that about one-half, or slightly less, of the above illumination intensities was required at the mouth of the mail bags in sack rack portion of car and on the face of the letter case. The following table, therefore, gives the minimum intensities which can be considered as sufficient for each of the three classes of equipment tabulated above.

Location.	Class 1 Equipment	Class 2 Equipment	Class 3 Equipment
Sack rack portion, center of car	1.40	2.24	2.80
Sack rack portion, mouth of bags	.75	1.20	1.50
Storage portion, measured not less than 18" from walls	.75	1.20	1.50
Letter cases, horizontal over tables	1.40	2.24	2.80
Letter cases, vertical, face of cases	.62	1.00	1.25

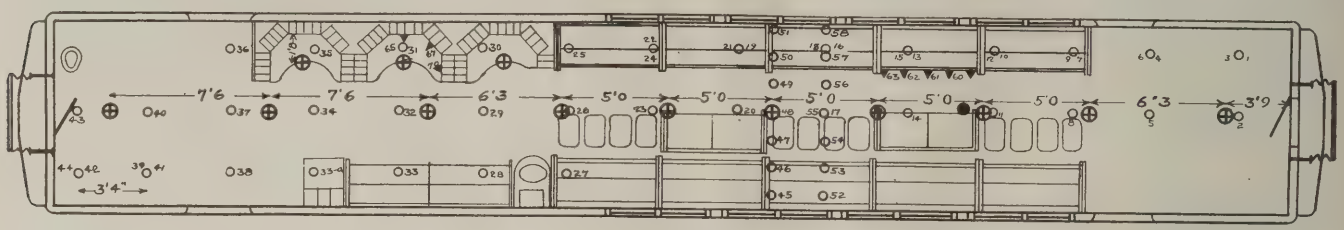
Depreciation Factors with Various Reflectors.

With spacing of light units shown on plan No. 1 for electric lighting and plan No. 2 for gas lighting the approximate amount of illumination provided in excess of the minimum values as stated in the above table, by the various reflectors tested, is given in the following table in the form of the per cent the initial values may fall before reaching the minimum:

No. 3044—82 c. p. mantle used in all instances except at letter case for aluminumized and enameled metal reflectors when 2640-27 c. p. mantle was used. For indirect lighting special 112 c. p. mantle was used.

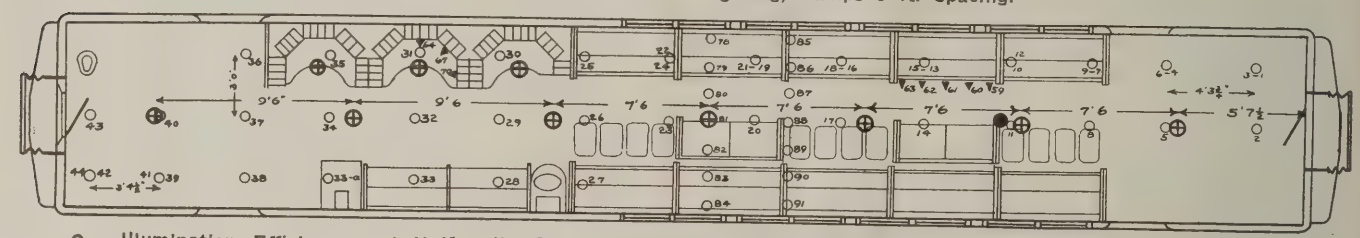
Suitability of Pintsch Gas Lighting.

4. The investigation showed that, when proper location of lamps and proper type of reflectors are provided, the illumination derived from Pintsch mantle gas lamps is in all ways equally satisfactory with that given by electric lighting. As in the case of electric lighting, the following conclusions were reached for Pintsch gas lighting. The best type of reflector for this service is the aluminumized metal reflector. Location of light units should be as specified in Conclusion No. 1, above. For satisfactory results units must not be spaced over 7½ feet apart in the sack rack portion, nor over 8 feet 6 inches in the storage portion of the car.



○ Illumination Efficiency and Uniformity Stations.
▲ Vertical Illumination Stations.
● Intensity Test Station.
⊕ Lamp Location.

Table No. 1. Test Plan Electric Lighting, Lamps 5 ft. Spacing.



○ Illumination Efficiency and Uniformity Stations.
▲ Vertical Illumination Stations.
● Intensity Test Station.
⊕ Lamp Location.

Table No. 2. Test Plan Gas Lighting, Lamps 7½ ft. Spacing.

	Sack Rack		Letter Case	
	Center	Mouth Bags	Storage	Horizontal	Vertical
Approximate per cent. depreciation from initial values for illumination to fall to minimum value specified.					
Electric Lighting.					
Mirrored glass X-Ray, No. 696..61	57	29*	68	54
Prismatic clear Holo., No. 18226, ⅝ position 56	62	44	56	22*
Prismatic S. F. Holo., No. 18226, SF. 58	52	43	55	32*
Heavy density opal Holo., No. 18626. 63	54	28	55	45
Medium density opal Phoenix CL-50. 56	54	31	50	32
Phoenix 10456 61	59	44	53	18
Macbeth-Evans, SF1623 59	58	51	52	31
Light density opal Macbeth-Evans, No. 3429 39	56	48	51	26
Aluminumized metal Holo. D'Olier, 18460 and 18470.....60	60	50	69	55
Enameled metal Holo. D'Olier, 18461 49	45	10	41	20
Reflecting and diffusing Adams & Westlake, No. 15050 48	45	1	41	14
Indirect lighting X-Ray, E-100.51	11	19	11	35
Gas Lighting.				
Aluminumized metal Holo. D'Olier, Nos. 18418 and 18490.66	68	60	77	68
Enameled metal Holo. D'Olier, 18417 and 18479 50	52	45	52	52
Reflecting and diffusing globe Safety Corona, No. 3425.....51	55	41	52	47
Safety Corona, No. 8026.....47	41	42	53	48
Safety, No. 3489 44	46	43	65	54
Diffusing globe Safety, No. 3116.36	35	23	59	40
Indirect lighting enameled reflector 51	34	17	—35	—18

*With two properly designed types of reflectors, one for letter case and one for body of car, as well balanced depreciation factors can be obtained with the mirrored and the prismatic reflectors as with the aluminumized metal.

Proper Size and Spacing of Electric Lamps.

5. On certain roads it has been the practice to employ 15-watt or 25-watt rather than 50-watt lamps in electric systems of postal car lighting. It was claimed for the smaller lamp system that it produced a more uniform illumination, and one characterized by less objectionable shadow conditions. The light units were frequently arranged in two parallel rows down the car, each row about 15 inches off the center line.

The investigation showed conclusively that equally satisfactory illumination results can be obtained with either 50-watt, 25-watt or 15-watt lamps. The smaller size of lamp should, however, like the larger size, be located in all cases on the center line of the car, except at the letter cases.

On account of its greater flexibility permitting just the adequate amount of light and no more to be supplied in each portion of the car, the use of the 25-watt or 15-watt sizes enables a saving of from 11 to 18 per cent to be made in electrical energy consumption. On the other hand, the use of these smaller sizes of lamps involves double fixture and reflector initial installation cost, and practically doubles the lamp and reflector maintenance cost.

To obtain adequate illumination results at all times in service, under prevailing conditions as to maintenance, the various sizes of light units should be located, when aluminumized metal reflectors are used,

SUMMARY OF ILLUMINATION TESTS

TABLE 1.

ELECTRIC LIGHTING

Nature of Value	ENTIRE CAR Foot candles	ENTIRE CAR % Useful Lumens	BAG RACK SECTION Ft. C. Center of car	BAG RACK SECTION Ft. C. Mouth Bags	BAG RACK SECTION Ft. C. Vertical on Pap. Bx.	LETTER CASE STORAGE SECTION Horizontal Ft. C.	LETTER CASE STORAGE SECTION Vertical Ft. C.	Foot candles
Division I.—Comparative Illumination Results, Various Types Reflectors, 5 ft. Spacing, 50 watt lamps.								
Mirrored Glass.....Avg.	6.03	62.3	12.04	3.77	3.74	10.75	4.67	3.84
X Ray No. 696.....Max.	17.90	....	17.90	3.98	4.74	13.70	7.04	8.90
5′ Spacing 1 3/16″ position.....Min.	2.12	....	7.28	3.37	2.16	8.80	2.72	2.12
Prismatic Clear.....Avg.	5.28	54.6	8.38	3.45	1.95	7.87	4.48	3.65
Holophane No. 18226.....Max.	14.65	....	9.36	3.69	2.46	9.52	6.67	6.76
5′ Spacing 1⅜″ position.....Min.	2.02	....	7.72	3.20	1.59	6.42	2.01	2.02
Heavy Density Opal.....Avg.	5.00	51.8	8.33	3.59	2.75	7.69	5.05	3.42
Holophane No. 18626.....Max.	11.55	....	10.38	3.93	4.06	9.03	8.54	6.46
5′ Spacing 1⅜″ position.....Min.	2.09	....	7.66	3.26	1.91	6.17	2.27	2.09
Aluminumized Metal.....Avg.	4.28	44.2	5.86	3.35	2.66	8.42	3.95	3.03
Holo. D'Olier 18460 and 18470.....Max.	9.51	....	6.14	3.57	3.69	9.51	5.86	5.19
5′ Spacing 1⅜″ position.....Min.	2.39	....	5.58	2.96	1.35	7.13	2.23	2.39
Medium Density Opal.....Avg.	4.14	42.8	6.31	3.43	4.01	5.36	3.01	2.96
Phoenix No. 10456.....Max.	8.45	....	7.62	3.72	4.65	5.72	5.09	5.50
5′ Spacing 1⅝″ position.....Min.	2.14	....	5.71	2.91	3.19	4.78	1.22	2.14
Medium Density Opal.....Avg.	4.13	42.7	5.96	3.44	3.82	5.50	3.76	3.07
Macbeth-Evans No. SF-1624.....Max.	8.47	....	7.04	3.68	4.63	6.04	6.58	5.39
5′ Spacing ⅝″ position.....Min.	.69*	....	5.40	2.87	2.70	4.89	1.56	.64*
Medium Density Opal.....Avg.	3.98	41.1	5.84	3.39	3.34	5.19	3.31	2.96
Macbeth Evans SF-1623.....Max.	7.85	....	6.65	3.68	4.20	5.54	5.90	4.90
5′ Spacing ⅝″ position.....Min.	2.38	....	5.43	2.86	2.51	4.71	1.45	2.38
Light Density Opal.....Avg.	3.93	40.6	5.87	3.28	3.82	5.23	3.18	2.93
Macbeth-Evans No. 3429.....Max.	7.45	....	7.45	3.52	5.06	6.22	5.47	4.75
5′ Spacing ¾″ position.....Min.	.68*	....	3.70	2.74	2.55	4.58	1.35	.69*
Enameled Metal.....Avg.	3.86	39.9	5.78	3.12	2.85	5.62	4.09	2.74
Holo. D'Olier 18461.....Max.	8.17	....	6.80	3.26	4.04	6.21	7.17	5.32
5′ Spacing 1⅜″ position.....Min.	1.67	....	5.48	2.76	1.75	4.77	1.56	1.67
Medium Density Opal.....Avg.	3.81	39.4	5.54	3.12	2.63	5.11	3.46	2.87
Phoenix CL-50.....Max.	7.92	....	6.30	3.28	3.14	5.68	5.58	5.11
5′ Spacing 1⅜″ position.....Min.	1.75	....	5.13	2.57	2.13	4.45	1.46	1.75
Prismatic Satin Finish.....Avg.	3.78	39.0	6.07	2.89	2.52	5.51	3.16	2.74
Holophane No. 18226 SF.....Max.	7.95	....	6.87	3.13	3.08	6.14	5.10	4.73
5′ Spacing 1⅜″ position.....Min.	2.09	....	5.36	2.51	1.99	4.95	1.46	2.09
Heavy Density Opal.....Avg.	3.73	38.5	5.51	3.14	4.27	4.98	3.63	2.84
Opalux No. 123.....Max.	7.00	....	6.15	3.36	5.52	5.26	6.60	5.33
5′ Spacing 1 3/16″ position.....Min.	2.11	....	5.07	2.58	2.83	4.65	1.34	2.11
Reflecting and Diffusing.....Avg.	3.06	31.6	4.79	2.45	4.14	4.34	....	2.18
Adams & Westlake No. 15050.....Max.	5.63	....	5.42	2.85	4.51	4.78	....	4.56
5′ Spacing.....Min.	1.21	....	4.32	2.16	3.63	3.82	....	1.21
Reflecting and Diffusing.....Avg.	2.63	27.2	4.25	2.04	3.66	4.24	2.20	1.83
Adams & Westlake No. 15090-15070...Max.	5.69	....	5.45	2.56	4.28	5.69	4.22	3.39
5′ Spacing.....Min.	.43*	....	3.55	1.94	3.17	3.25	.92	.43*
Bare Lamps.....Avg.	2.71	28.0	3.79	2.46	4.36	2.72	1.94	2.10
5′ Spacing.....Max.	5.20	....	4.11	2.84	4.59	2.93	3.86	3.69
Min.	1.65	....	3.42	2.00	4.14	2.56	.59	1.65
Division II.—Same as Division I, Except 7½ ft. Spacing.								
Heavy Density Opal.....Avg.	4.20	56.4	5.87	2.76	1.74	7.83	....	3.04
Holophane No. 18626.....Max.	12.52	....	9.49	3.76	3.35	9.79	....	8.83
7½′ Spacing 1⅜″ position.....Min.	1.03	....	4.63	2.38	.98	6.51	....	1.03
Prismatic Clear.....Avg.	3.97	53.4	6.13	2.47	1.17	6.94	4.48	2.92
Holophane No. 18226.....Max.	11.30	....	8.39	3.40	1.60	7.67	6.67	8.00
7½′ Spacing 1⅜″ position.....Min.	.89	....	4.79	1.97	.97	6.14	2.01	.89
Aluminumized Metal.....Avg.	3.38	45.3	4.37	2.50	1.46	7.64	3.95	2.43
Holo. D'Olier 18460 and 18470.....Max.	8.84	....	5.21	2.83	3.38	8.84	5.86	4.50
7½′ Spacing 1⅜″ position.....Min.	1.15	....	4.02	2.23	.58	6.87	2.23	1.15
Enameled Metal.....Avg.	3.23	43.4	4.39	2.38	1.47	5.44	4.09	2.52
Holo. D'Olier 18461.....Max.	7.94	....	6.70	3.00	2.97	6.31	7.17	5.42
7½′ Spacing 1⅜″ position.....Min.	1.26	....	3.68	2.08	.80	4.67	1.56	1.26
Medium Density Opal.....Avg.	3.10	43.0	4.26	2.45	1.89	4.46	3.31	2.36
Macbeth Evans SF-1623.....Max.	6.76	....	6.02	3.12	3.18	4.83	5.90	4.46
7½′ Spacing ⅝″ position.....Min.	1.32	....	3.65	2.25	1.25	4.04	1.45	1.32

*Minimum value given is for point falling behind an obstruction.

TABLE 1.—(Continued.)
SUMMARY OF ILLUMINATION TESTS
ELECTRIC LIGHTING

Installation	Nature of Value	ENTIRE CAR Foot candles	ENTIRE CAR % Useful Lumens	BAG RACK SECTION Ft. C. Center of car	BAG RACK SECTION Ft. C. Mouth Bags	BAG RACK SECTION Ft. C. Vertical on Pap. Bx.	LETTER CASE SECTION Horizontal Ft. C.	LETTER CASE SECTION Vertical Ft. C.	STORAGE SECTION Foot-candles
Division II (Continued).—Same as Division I, Except 7½ ft. Spacing.									
Prismatic satin finish	Avg.	3.09	41.5	4.28	2.17	1.63	5.27	3.16	2.36
Holophane No. 18226-SF	Max.	8.26	....	6.36	2.78	2.34	6.28	5.10	5.46
7½′ Spacing 1⅜″ position	Min.	.71*	....	3.54	1.97	1.27	4.52	1.46	.72*
Medium Density Opal	Avg.	2.94	39.5	4.28	2.07	1.41	4.82	3.01	2.18
Phoenix No. 10456	Max.	6.86	....	5.62	2.98	2.01	5.35	5.09	4.54
7½′ Spacing 1⅜″ position	Min.	.68*	....	3.46	1.61	1.11	4.46	1.35	.68*
Reflecting and Diffusing	Avg.	2.38	32.0	3.49	1.69	2.40	3.92	3.01	1.80
Adams & Westlake No. 15050	Max.	4.94	....	4.72	2.27	3.65	4.43	5.10	3.80
7½′ Spacing	Min.	.75*	....	2.88	1.54	1.72	3.22	1.15	.75*
Division III.—Same as Division I, Except 10 ft. Spacing.									
Aluminumized Metal	Avg.	2.50	42.0	3.01	1.58	2.78	6.68	3.95	1.97
Holo. D'Olier 18460 and 18470	Max.	7.56	....	4.28	2.29	5.72	7.56	5.86	4.72
10′ Spacing 1⅜″ position	Min.	.15*	....	1.99	.15*	.39	5.74	2.23	.42*
Medium Density Opal	Avg.	2.30	38.6	3.13	1.43	2.00	4.49	3.31	1.88
Macbeth-Evans SF-1623	Max.	6.48	....	4.46	2.09	3.37	5.15	5.90	4.98
10′ Spacing ⅝″ position	Min.	.34*	....	1.69	.34*	.77	4.00	1.45	.44*
Division IV.—Results with Indirect Lighting System. 50 Watt Lamps with 10 ft. Spacing.									
Mirrored Glass Indirect Lighting	Avg.	2.37	26.1	3.34	1.82	1.46	1.90	1.49	2.05
X-Ray E-100-50 Watt Lamps	Max.	4.26	....	3.87	2.24	1.78	2.18	1.99	4.26
10′ Spacing	Min.	.84	....	2.89	.84	1.14	1.58	.95	.93
Division V.—Results With 15 Watt Lamps. Compare With Division I.									
Prismatic Clear	Avg.	2.73	53.1	5.02	2.15	1.78	3.50	1.72	1.88
Holophane No. 1822	Max.	5.78	....	5.78	2.65	2.86	4.17	2.33	4.84
5′ Spacing ⅝″ position	Min.	.18*	....	4.30	1.68	.85	2.28	1.04	.18*
15-watt lamps.									
Aluminumized Metal	Avg.	2.28	44.6	3.63	2.10	2.34	2.28	1.69	1.62
Holo. D'Olier 18440	Max.	4.15	....	3.96	2.23	3.54	2.71	3.05	2.77
5′ Spacing "O" position	Min.	.58	....	3.32	1.99	.98	1.50	.57	.58
15 Watt Lamps									
Medium Density Opal	Avg.	2.12	41.2	3.37	1.94	2.41	2.17	1.21	1.54
Macbeth-Evans No. 2619	Max.	3.80	....	3.70	2.16	3.05	2.53	2.20	2.59
5′ Spacing "O" position	Min.	.37*	....	3.10	1.77	1.67	1.72	.46	.37*
15-watt lamps.									
Division VI.—Effect of Using Body of Car Type of Reflector at Letter Case. Compare With 4th Test, Division I.									
Aluminumized Metal	Avg.	4.07	42.1	5.86	3.35	2.66	5.47	4.25	3.03
Holo. D'Olier 18460	Max.	8.42	....	6.14	3.57	3.69	6.00	7.59	5.19
5′ Spacing 1⅜″ position	Min.	.33*	....	5.58	2.96	1.35	4.86	1.54	.33*
Division VII.—Results With Dirty Reflectors. Compare With 4th Test, Division I.									
Aluminumized Metal	Avg.	3.13	32.3	4.46	2.58	....	5.35	....	2.26
Holo. D'Olier 18460 and 18470	Max.	6.21	....	4.92	2.83	....	5.73	....	4.36
5′ Spacing 1⅜″ position	Min.	.29*	....	4.26	2.35	....	4.74	....	.29*
Dirty reflectors.									
Division VIII.—Effect of Change of Lamp Position on Illumination Values. Compare With 2nd Test, Division I.									
Prismatic clear	Avg.	4.22	43.6	5.73	3.85	3.51	5.27	3.99	3.15
Holophane No. 18226	Max.	8.28	....	6.98	4.24	4.85	5.57	7.78	5.10
5′ Spacing ⅝″ position	Min.	.6*	....	5.12	3.20	2.03	5.06	1.28	.65*

at approximately the spacing shown in the following table. If a less efficient type of reflector be used, the units must be spaced more closely, or better maintenance than is now the general practice must be provided.

Electric Lighting.

Maximum separation between adjacent units.

Location.	50 watt unit	25 watt unit
Sack rack portion	5′ 0″	2′ 10½″
Storage portion	7′ 6″	4′ 6″
Letter case portion Standard cases (as used in full postal cars) up to 4′ 9″ width (7 letter boxes wide, back case)	1 unit	2 units
Standard cases from 4′ 9″ width to 6′ 9″ (12 letter boxes)	2 units	3 units

Proper Size and Spacing Pintsch Mantle Lamps.

In the case of Pintsch mantle gas lighting, it was found that equally satisfactory illumination results could be obtained with a No. 3044 mantle, giving approximately 82 mean horizontal candle power, as with smaller size mantles. As the No. 3044 mantle is in general commercial use for postal car lighting there is no advantage to be gained by the use of smaller mantles except at the letter cases when aluminumized metal reflectors are used. Because of the character of distribution curve obtained with the proper design of reflector of this type for letter case illumination and because of its high efficiency the use of the small mantle is required to keep the maximum illumination values within desirable limits. To obtain adequate illumination at all times in service, when

*Minimum value given is for point falling behind an obstruction.

TABLE 2.
SUMMARY OF ILLUMINATION TESTS
GAS LIGHTING

Installation	Nature of Value	ENTIRE CAR Foot candles	ENTIRE CAR % Useful Lumens	BAG RACK SECTION Ft. C. Center of car	BAG RACK SECTION Ft. C. Mouth Bags	BAG RACK SECTION Ft. C. Vertical on Pap. Bx.	LETTER CASE SECTION Horizontal Ft. C.	LETTER CASE SECTION Vertical Ft. C.	STORAGE SECTION Foot-candles
Division IX.—Comparative Illumination Results, Various Types Reflectors and Globes, 7½ ft. Spacing, Mantle No. 3044.									
Aluminumized Metal	Avg.	5.95	44.5	7.24	4.07	2.30	15.4	6.08	4.78
Holo. D'Olier 18418 and 18490	Max.	17.10	....	7.96	4.59	5.16	17.10	8.90	8.33
(Mantle No. 3044) 7½′ Spacing	Min.	2.47	....	6.51	3.65	.93	12.55	3.69	2.97
Aluminumized Metal	Avg.	5.41	40.1	5.72	4.03	4.54	15.05	6.08	4.05
Holo. D'Olier 18410 and 18490	Max.	17.20	....	6.26	4.47	9.18	17.20	8.90	6.75
(Mantle No. 3044) 7½′ spacing	Min.	2.62*	....	4.52	3.20	2.03	11.90	3.69	2.62*
Enameled metal	Avg.	4.91	37.2	6.66	3.72	3.78	9.40	6.32	4.24
Holo. D'Olier 18417 & 18479	Max.	11.88	....	7.37	4.06	8.90	11.88	11.80	7.78
Mantle No. 3044 7½′ spacing	Min.	2.29	....	5.60	3.13	1.60	7.12	2.59	2.29
Enameled Metal	Avg.	4.27	32.0	5.50	3.07	2.72	8.76	6.32	3.55
Safety No. 8409, Center 8465	Max.	10.20	....	7.09	3.64	5.23	10.20	10.56	7.54
7½′ Spacing (No. 3044 mantle)	Min.	1.30*	....	4.23	2.34	1.33	7.67	2.62	1.30*
Reflecting and Diffusing Globe	Avg.	4.10	30.7	5.47	3.47	5.26	5.20	5.04	3.46
Safety Corona No. 3425	Max.	7.80	....	6.79	6.00	6.26	5.83	8.85	6.23
(Mantle No. 3044) 7½′ Spacing	Min.	2.04	....	4.59	2.63	4.60	4.67	1.89	2.04
Reflecting and Diffusing Globe	Avg.	4.05	30.3	5.26	2.92	4.73	6.49	4.60	3.44
Safety No. 3489 (Mantle No. 3044)	Max.	8.74	....	6.48	3.35	6.55	6.56	7.33	6.55
7½′ Spacing	Min.	1.72	....	3.97	2.21	3.74	6.35	2.18	1.72
Reflecting and Diffusing globe	Avg.	3.86	28.9	5.18	2.85	4.56	5.56	4.05	3.37
Safety Corona No. 8026	Max.	8.23	....	5.95	3.23	6.05	6.22	6.60	6.20
Mantle No. 3044, 7½′ Spacing	Min.	2.00	....	4.25	2.42	3.72	4.83	1.93	2.00
Diffusing globe—Opal	Avg.	3.27	24.0	4.58	2.19	3.48	5.59	3.20	2.79
Safety No. 3116, No. 3044 mantle	Max.	6.81	....	5.63	2.63	4.73	5.94	4.94	5.79
7½′ spacing	Min.	1.50	....	3.52	1.84	2.80	5.41	1.69	1.50
Division X.—Results With Safety Mantle No. 3044 in Body of Car and No. 2640 at Letter Cases.									
Aluminumized metal	Avg.	4.88	45.0	5.61	4.01	4.54	11.22	5.15	3.92
Holo. D'Olier 18410 & 18490	Max.	13.50	....	6.26	4.47	9.18	13.50	7.51	5.48
3044 and 2640 mantle 7½′ spacing	Min.	2.78	....	4.52	3.09	2.03	9.63	3.05	2.92
Reflecting and Diffusing Globe	Avg.							3.87	
Safety Corona No. 3425	Max.	(Only Vertical Readings in letter cases taken.)						6.53	
(Mantles 3044 and 2640) 7½′ Spacing	Min.							1.59	
Division XI.—Effect of Using Body of Car Type of Reflector at Letter Case. Compare With 1st Test, Division IX.									
Aluminumized Metal	Avg.	5.80	43.4	7.36	4.08	2.30	9.45	7.54	4.84
Holo. D'Olier 18418	Max.	14.70	....	8.18	4.59	5.16	9.62	12.90	8.33
(Mantle No. 3044) 7½′ spacing	Min.	2.03	....	6.51	3.66	.93	9.31	3.14	2.03
Division XII.—Results With Indirect Lighting System, Large Special Type Safety Mantle, 10 ft. Spacings.									
Enameled metal Indr. Ltg.	Avg.	2.06	18.9	3.13	1.70	1.36	1.38	.77	1.95
Safety mantle No. "125 C.P."	Max.	3.35	....	3.34	2.20	1.56	2.02	1.03	3.14
10′ spacing	Min.	.90	....	2.88	1.13	1.19	1.04	.51	.90
Division XIII.—Oil Lighting.									
Adams & Westlake Acme Lamps	Ave.	2.40	....	2.75	3.35	3.07	2.47	2.18	1.69
7½′ spacing	Max.	4.11	....	3.43	3.26	4.05	2.61	2.93	3.67
	Min.	.38	....	2.17	1.71	2.56	2.22	1.47	.38

aluminumized metal reflectors are used, mantle gas lamps should be located at approximately the spacings shown in the following table:

Pintsch Gas Lighting.

Location	Maximum Separation between Adjacent Units. Mantle No. 3044, approximately 82 c. p.
Sack rack portion	7′ 8″ (7′ 6″ preferable)
Storage portion	8′ 6″
Letter case portion—Standard cases (as used in full postal cars) up to 5′ 6″ width (9 letter boxes wide, back case)	1 unit using No. 2640 mantle giving approximately 27 mean horizontal candle power.
Standard cases 6′ 9″ (12 letter boxes	2 units using No. 2640 etc.

Feasibility of Indirect Lighting.

6. The indirect lighting system showed conclusively that this system produced an illumination so favorable to the efficient operation of the eye that adequate illumination was obtained with very much less the intensity required when mirrored or porcelain enameled reflectors were employed. Taking this into account, it was found that an adequate intensity of illumination can be obtained with the indirect system without any prohibitive or seriously objectionable increase in consumption of electricity or gas. This is based on the assumption of initially providing for only the same amount of depreciation as given by many of the direct systems on 5-foot spacing.

It should be remembered, however, that the efficiency of the indirect system depends directly upon

*Minimum value given is for point falling behind an obstruction.

the reflecting powers of the ceiling, while the various direct systems are practically independent of ceiling reflection. Even with reasonably frequent thorough cleanings of the ceiling, say every two months, and with repainting once a year, a higher factor of depreciation should be provided for the indirect system than for the direct system. This would involve an objectionably high gas consumption in gas-lighted cars, and a still more objectionably high, if not prohibitive, electric consumption in electric-lighted cars. Moreover, it is considered unlikely that any railway organization would feel inclined to provide the degree of maintenance necessary.

In addition to the above considerations, the paper boxes very seriously shade the illumination on the rear sacks and rear sack rack label, though they cast no defined shadow.. To bring the illumination at these points up to an intensity which would be considered adequate, even with the indirect system, would involve an expenditure of gas or electrical energy which could not be regarded as other than prohibitive.

Because, therefore, of the constructional features of the postal car, and because the conditions of its service involve unusual difficulties in maintaining the reflecting qualities of the head lining, the indirect lighting system is considered decidedly impracticable for postal car illumination in the present state of the art.

Loss of Illumination with Poor Reflector Cleaning Practice.

7. The loss in illumination due to dirty reflectors, globes or lamps, is much larger than usually realized. Aluminumized metal reflectors which had been in service nine months, receiving no cleaning other than that usual with present practice, showed a loss in illumination of 30 per cent over that with new reflectors. To obtain full benefits from the use of efficient and scientifically designed lighting units will require materially higher standard of cleaning practice, in connection with which serious consideration should be given to the practice, at important terminals, of cleaning reflectors separate from the cars at a central point where adequate facilities can be provided.

RECOMMENDATIONS.

It is recommended for practice of postal car lighting:

First—That lighting units for body of car be located along center line.

Second—That illumination at letter cases be provided by separate lighting units 20 inches in front of face of standard case.

Third—That all units be mounted 7 feet 6 inches from floor to center of filament or gas mantle.

Fourth—That aluminumized metal reflectors be used for both electric and gas lighting, one type for body of car, and separate type for letter cases.

Fifth—That with Pintsch gas lighting mantle lamps giving approximately 80 mean horizontal candle power be used for body of car and 30 mean horizontal candle power for letter cases.

The Illumination of Postal Cars

A Discussion of the Recent Series of Tests, With Various Installation Layouts

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The issuance by the United States' Post Office Department, on December 28, 1912, of very complete specifications[1] covering the lighting of postal cars was an event of notable scientific interest and significance to the illuminating engineer, on the one hand, and of large practical importance to the railway electrical engineer and railway car builder on the other. To the illuminating engineer the event was notable, first, because this was the first example of specifications drawn to permit the use of any type of light unit whatsoever, without any discrimination except such as was necessarily involved in insuring that the lighting service provided should be thoroughly adequate in all respects; and second, because here, for the first time, was official recognition given to the fact that the foot-candle intensity required for adequate illumination varies directly according to the diffuseness of the illumination provided. To the railway engineer and car builder the event was important because the specifications established a definite and, in all probability, permanent standard of postal car lighting practice applying equally to all postal cars, by whatever railroad operated, and in whatever part of the United States. The standard established could by no means be considered burdensome, for it represented an installation less costly to install and maintain than several of the types of installation previously employed on an extensive scale by railroads of first-class standing. The standard, while fixed and definite in matters essentially affecting the quality of lighting service to be provided, was so sufficiently flexible that it could be fitted in without burden to the railroad's standard practice in other classes of car lighting service. The advantages of such a standard to the railway interests and to car builders are too obvious to require comment.

In order to avoid discrimination against any type of reflector or illuminant, yet at the same time to safeguard the adequacy of the illumination results produced, in order to make the specifications flexible and readily adaptable to each railway's standard practice, yet at the same time not to sacrifice the quality of the illumination service provided, it was necessary that the specifications be written in terms of the results to be achieved. Some features of the installation could be and were definitely specified, as, for instance, the location of body of car units on the center line of the car and the location of letter case units approximately 20 inches in front of the face of the case. But the separation between adjacent units, for instance, could not be definitely specified without marked discrimination against one type or another of reflector or illuminant. Again, the mounting height of the light unit or the size of incandescent lamp or gas mantle to be employed could not be definitely specified without unnecessarily hampering the adaptability of the specifications to the railway company's standard practice.

The fact that the specifications are drawn up in general terms of the results to be achieved has led

[1]These were embodied as paragraph 33 of the Specifications for the Construction of Steel Full Postal Cars, revised to Dec. 28, 1912.

to certain difficulties, trivial for the most part, yet temporarily none the less real, in their interpretation and application to practice. It is the purpose of the present article to explain and rather fully comment on the various features of the specifications, as a means of assistance in their future interpretation and application. The writer had the privilege of assisting in the preparation of the specifications, so that the following comments have whatever weight may be derived from the most intimate knowledge of the data on which the specifications are based and of the circumstances surrounding the formulation of the specifications.

For convenience in reference, the various considerations set forth are grouped under subject heads in the following paragraphs:

Location of Unit.

The arrangement of letter boxes and sack racks in the sack rack portion of the car is the essential constructional feature which determines the location of the light units throughout the body of the car. Figure 1 illustrates the considerations involved. On the one hand, the light units should be mounted as high above the floor as possible, in order to keep them as far as possible out of the field of vision when the postal clerk glances up or down the car. On the other hand, it is obvious that the light unit must not be mounted so high as to throw the shadow of the paper boxes on the rear sack rack labels. These two considerations make it necessary that the light units be mounted on the center line of the car, as otherwise either the shadow of one of the paper boxes would be thrown on the rear labels beneath, or else the light units would have to be mounted objectionably low.

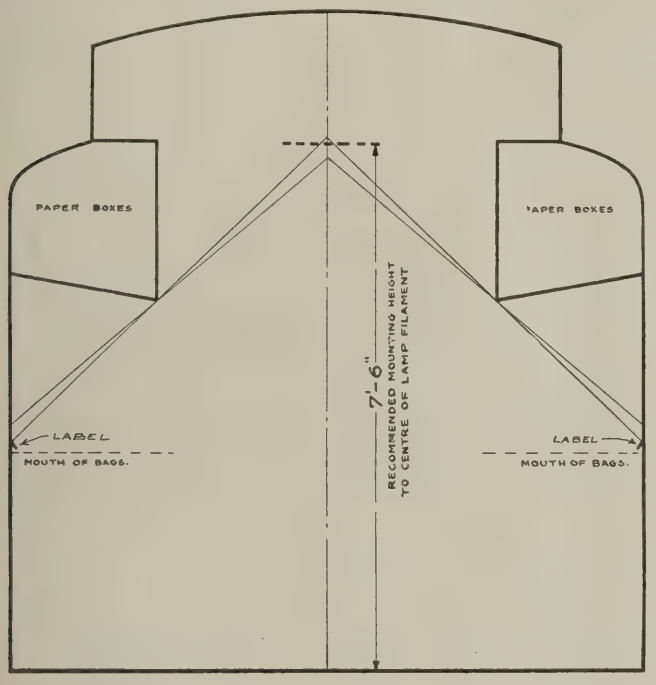


FIG. 1.

—CONSIDERATIONS AFFECTING—
MOUNTING HEIGHT OF LIGHT UNIT.

The ideal mounting height is that which throws the shadow of the paper boxes just barely above the labels. In the new standard car construction this best mounting height is 7 feet 6 inches, measured from the floor to the center of the lamp filament.

In formulating the specifications, it was thought desirable to permit as much flexibility in the matter of mounting height as might be given without interfering with the satisfactoriness of the installation. The specifications accordingly provide that the shadow of the paper boxes shall not be cast on the rear labels nor more than 3 inches above the rear labels. This feature of the specifications has led to a curious misunderstanding. In two proposed installations which have been laid before the writer for his criticisms, the mounting height has been so arranged as to bring the shadow 3 inches above the rear labels. The attention here called to this feature of the specifications, and a careful reading of the specifications themselves, will emphasize the fact that the 3-inch value is a limit, and not a specified value as to desirable practice. The shadow of the paper boxes should fall less than 3 inches above the rear labels, unless there is some adequate reason in the particular railway's standard practice why the limit value should be employed.

The presence of the paper boxes presents one of the chief obstacles to the successful employment of indirect lighting in postal cars. In the indirect system, the center deck headlining itself becomes essentially the light source. While shadows are impossible with the indirect system, the paper boxes shade the area directly beneath them to a considerable degree. No objectionable shadows are cast on the rear labels, but the shading influence of the paper boxes is such that it is difficult with the indirect system to attain the specified foot candle intensities at the mouths of the bags, 18 inches from the sides of the car. In the opinion of the writer, it is the above feature, rather than the lower illuminating efficiency of the indirect system, which makes indirect lighting impractical at the present time for the service in question.

The above considerations definitely locate the light units for lighting the sack rack portion of the car on the center line of the car at an approximate height of 7 feet 6 inches above the floor, measured to the center of the lamp filament. Considerations of convenience and economy in making the installation will dictate that the light units in the storage portion of the car be likewise mounted on the center line at the same mounting height. This arrangement in the storage portion is not only the most convenient from a practical standpoint, but gives the most satisfactory illumination results, though certain other arrangements could be employed without serious sacrifice.

At the letter case, the question of shadows again determines where the light unit should be located. It is imperative that the head and shoulders of the postal clerk shall cast no shadow on the face of the letter case nor on the letters which he holds in his hands while sorting. With the present standard width of letter case table, and assuming the light units are to be mounted at the same height as the units in the body of the car, 20 inches is the maximum distance at which the units can be mounted in front of the face of the case without casting an objectionable shadow. When narrower tables are used, as at the registered mail case, the above distance has to be made correspondingly less than 20 inches.

It is, for obvious reasons, necessary to provide sufficient illumination at all points on the face of the case. Now it is a well known principle of illuminating engineering that the more obliquely the light rays strike any given surface, the less power they have in illuminating that surface. If the light unit be located close to the face of the case, its rays will strike the lower portions of the face of the case at a very oblique angle, and hence have very low illuminating power. In order, therefore, to adequately illuminate the lower portion of the face of the case, the light unit should

be as far as possible in front of the face of the case. We have seen above that it cannot be further than 20 inches without casting an objectionable shadow. Twenty inches in front of the face of the case is therefore the definitely-established location, when the letter case table is of the present standard width.

The above considerations make clear that portion of the specifications which provide that illumination requirements at the letter case shall be entirely fulfilled by the letter case units, other units in the car not burning. Obviously the effect of units located on the center line of the car is to cast a [1]shadow of the postal clerk on his work, so that the light emitted by such units is, to all essential purposes, useless in illuminating the work. It may be stated in passing that care should be taken in locating any units on the center line of the car near the letter cases. The satisfactory illumination of the body of the car requires, in one or two types of construction, the employment of such center line units near the cases, but unless the location is chosen with care, such units may cast somewhat annoying shadows.

It will be obvious that if the letter case units were mounted considerably higher than the units for light-

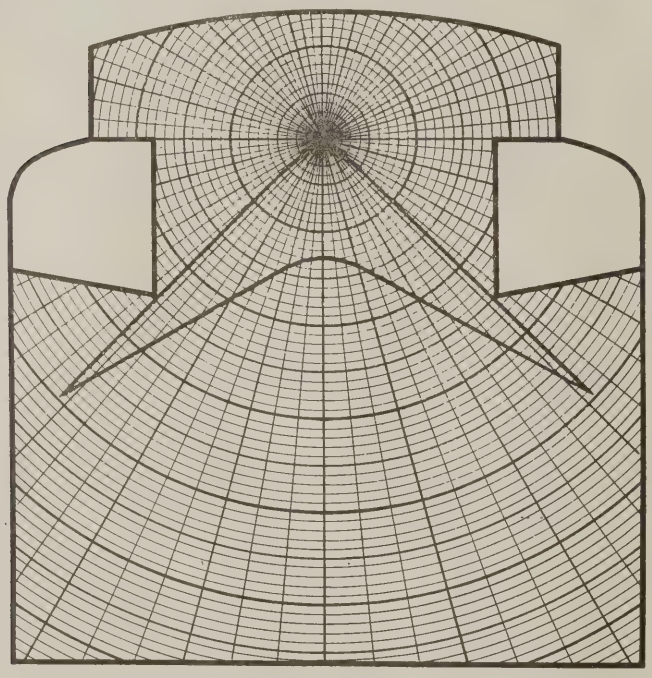


FIG. 2
THEORETICAL CURVE OF LIGHT DISTRIBUTION.
——SACK RACK PORTION OF CAR.——

ing the body of the car, they might be mounted more than 20 inches in front of the face of the case without producing objectionable shadow effects. Such practice would, however, give lower illumination values on the face of the case. It was also considered that such practice would be undesirable from the standpoint of economy of installation and of neat appearance of installation. The specifications therefore definitely provide that the light units at the letter cases shall be mounted at the same height from the floor as the units in the body of the car.

Distribution Requirements in Body of Car and at Letter Case.

Figure 2 and Figure 3 show, respectively, the distribution requirements in the sack rack portion of the car and at the letter case. An inspection of these two theoretical distribution curves suggests at once that the satisfactory reflector for lighting the letter case will have to be of a different type than that employed

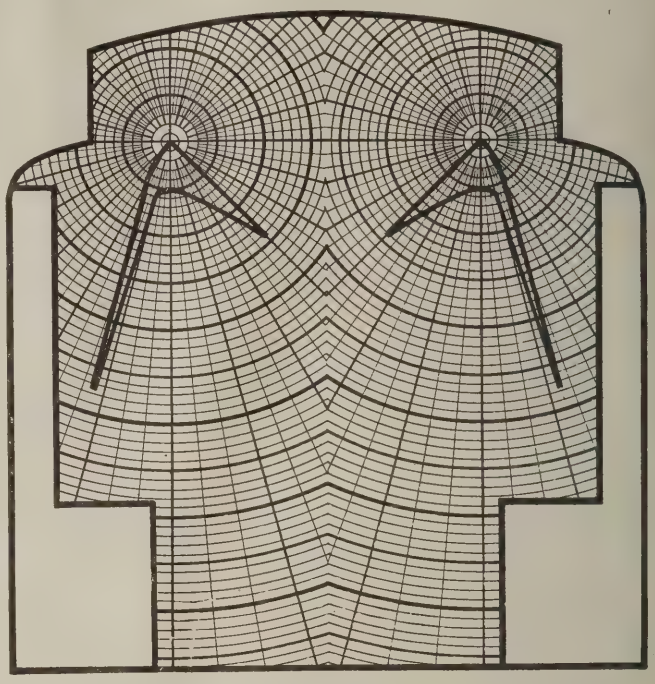


FIG. 3.
THEORETICAL CURVE OF LIGHT DISTRIBUTION
——— LETTER CASE ———

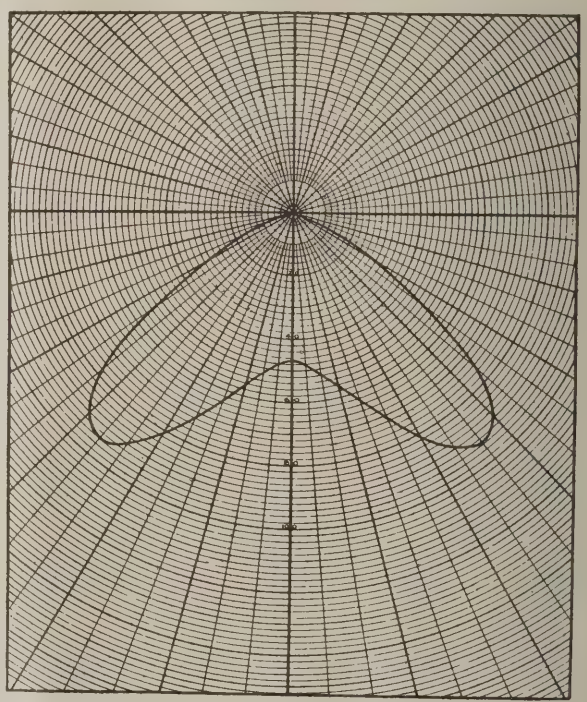


Fig. 4. Distribution Curve of Center of Car Type Reflector No. 12460.

in lighting the body of the car. Extensive actual tests show this to be, beyond question, the case. If the type of reflector which is satisfactory for lighting the body of the car is employed at the letter case, the upper third of the face of the case will be much too brightly illuminated while the lower third of the case will be decidedly too poorly illuminated. Indeed, it will usually be found that, if the attempt is made to

[1]This statement applies especially to the more usual type of construction in which wing letter cases are located on the sides of the car. It also applies, but with lesser force, to the construction where the letter case is located at the end of the car.

employ at the letter case a type of reflector suitable for lighting the body of the car, the maximum illumination limits of the specifications will be exceeded near the upper part of the face of the case before the minimum limits of the specifications are reached at the lower part of the case.

The theoretical requirements for lighting the letter case, as shown in Figure 3, are of course entirely impracticable of actual realization. These requirements are best approximated by a reflector having a moderately concentrating type of distribution. This statement needs to be especially emphasized in view of the widely held but mistaken idea that an angle reflector will most satisfactorily meet the letter case illumination requirements. It will be noted (Figure 3) that the maximum candlepower is required at an angle of about 15°, and that, as this angle of maximum candle power is exceeded, the candle power values drop off very rapidly. It is impossible in the case of an angle reflector to bring about this rapid decrease in candle power. The tendency of an angle reflector is therefore to give a much too high illumination at the middle and upper third of the face of the case, and a somewhat too low illumination over the lower third.

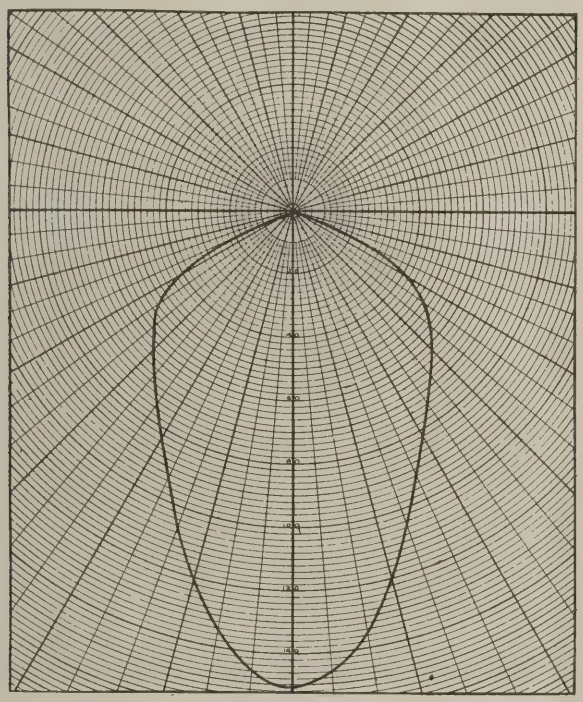


Fig. 5. Distribution Curve of Letter Case Type Reflector No. 18470.

Figures 4 and 5 are the curves of actual postal car lighting reflectors designed to approximate as closely as practicable the theoretical curves of figures 2 and 3.

Since the illumination requirements at the letter cases call for a concentrating type of light distribution, the satisfactory reflector at the letter case must act according either to the Law of Specular Reflection or to the Law of Spread Reflection.[1] The only reflectors which reflect in accordance with either of the above laws are the aluminumized metal reflector, the prismatic reflector (clear or satin finished), and the mirrored glass reflector. In other words, satisfactory illumination at the letter case can only be provided by one of the above types of reflector. It is absolutely impossible to design any other type, such as the porcelain enameled metal reflector, for instance, so as not to produce an undesirably high illumination on the upper face of the case while giving, at the same time, an insufficient illumination on the lower face.

Size of Unit.

The extensive tests which have been made in postal car lighting have demonstrated that satisfactory uniformity of illumination may be produced in the sack rack portion of the car up to a separation of about 8 feet between adjacent units. The idea held by some, that smaller units than the 50 watt tungsten filament lamp are required in order to produce satisfactory uniformity, is thus shown to be erroneous. Equally satisfactory illumination results can be produced with the 50 watt lamp and with any of the smaller sizes of lamp. The only advantage in using the smaller sizes of lamp is that of a slight decrease in total wattage required, this decrease resulting from the greater economy of arrangement made possible with the smaller unit. Against this saving in wattage must be weighed the disadvantage of a considerably higher installation and maintenance cost, resulting from the use of the larger number of separate units. From an illumination standpoint, the results are equally satisfactory whether the 50 watt lamp or a smaller lamp be employed; but it is the firm belief of the writer that the advantages in decreased installation and maintenance costs will gradually lead to the all but universal adoption of the 50 watt lamp in electrical postal car lighting practice.

In Pintsch gas installations, the tests on postal car lighting have shown that mantle No. 3044 is the most satisfactory size of mantle for the body of the car, while mantle No. 2640 is the most satisfactory size at the letter cases.

Installation Layouts.

Several railway engineers have expressed regret that the specifications do not definitely specify the separation between adjacent units. It would, of course, be impossible to so specify the separation without discrimination as between different types of reflector equipment. The more satisfactory types of reflector equipment permit, with fully as good illumination results, a separation twice as great as that permitted by the least satisfactory types, the same lamps being used in both cases. Obviously, if the specifications were to cover spacing values, and these were to be based on the least satisfactory reflector equipment, the more satisfactory reflectors would be discriminated against, and railroads employing them would be penalized by being forced to put in twice as many units as would

[1] A full discussion of this subject will be found in the writer's paper, "Reflecting Media," appearing in the January, 1913, issue of the *Railway Electrical Engineer*.

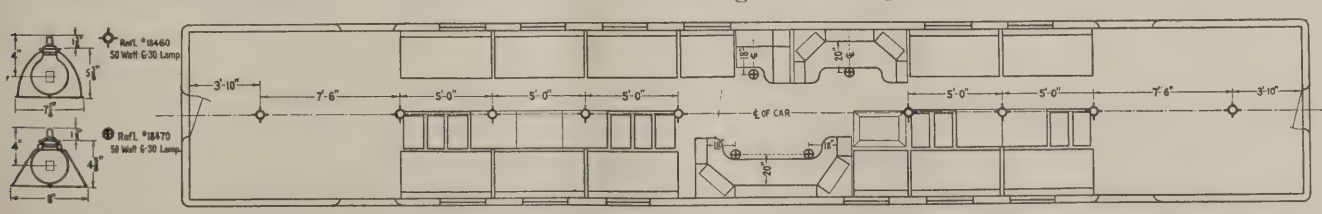


Fig. 6. Layout for 60 ft. Postal Car Using 50 Watt Mazda Lamps With Holophane D'Olier Aluminumized Metal Reflectors.
(All Units Mounted 7 ft. 6 ins. Above the Floor Measured to the Center of Lamp Filament.)

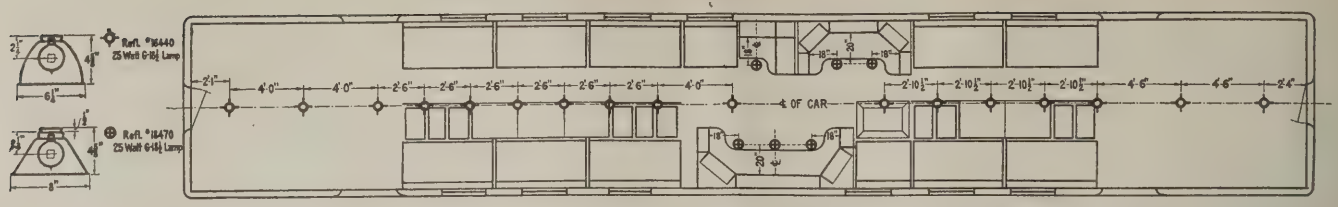


Fig. 7. Layout for 60 ft. Postal Car Using 25 Watt Mazda Lamps With Holophane D'Olier Aluminumized Metal Reflectors.
(All Units Mounted 7 ft. 6 ins. Above the Floor Measured to the Center of Lamp Filament.)

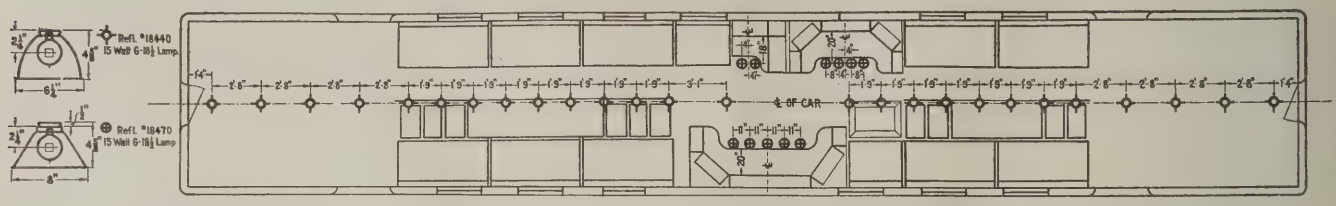


Fig. 8. Layout for 60 ft. Postal Car Using 15 Watt Mazda Lamps With Holophane D'Olier Alumniumized Metal Reflectors.
(All Units Mounted 7 ft. 6 ins. Above the Floor Measured to the Center of Lamp Filament.)

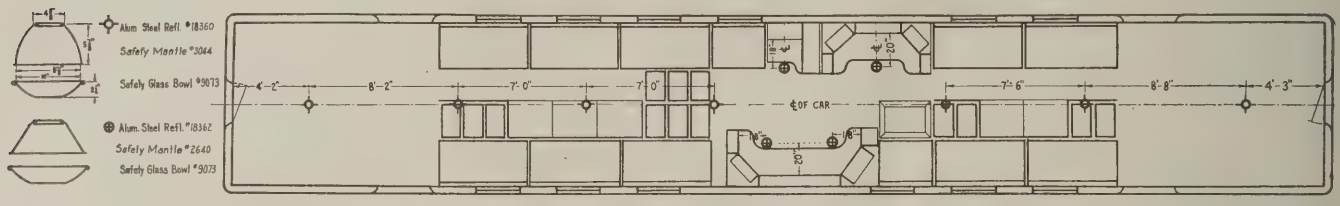


Fig. 9. Layout for 60 ft. Postal Car Using Pintsch Gas Mantle No. 3044 and No. 2640 with Holophane D'Olier Aluminumized Metal Reflectors.
(All Units Mounted 7 ft. 6 ins. Above the Floor Measured to the Center of the Mantle.)

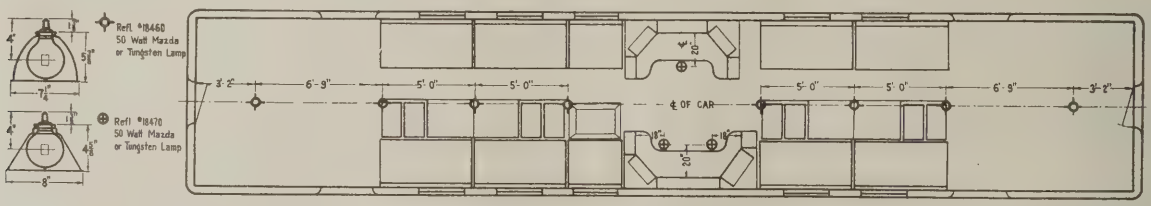


Fig. 10. Layout for 50 ft. Postal Car Using 50 Watt Mazda Lamps With Holophane D'Olier Aluminumized Metal Reflectors.
(All Units Mounted 7 ft. 6 ins. Above the Floor Measured to the Center of Lamp Filament.)

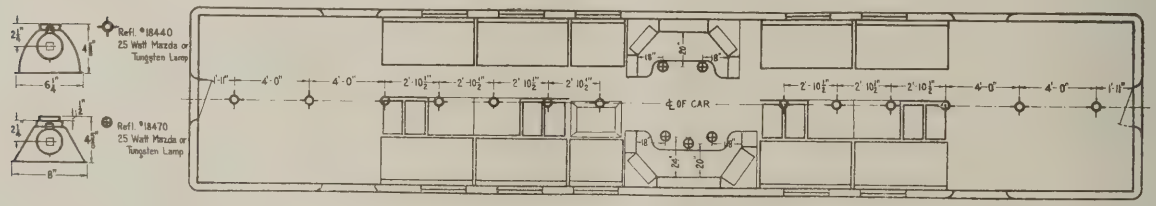


Fig. 11. Layout for 50 ft. Postal Car Using 25 Watt Mazda Lamps With Holophane D'Olier Aluminumized Metal Reflectors.
(All Units Mounted 7 ft. 6 ins. Above the Floor Measured to the Center of Lamp Filament.)

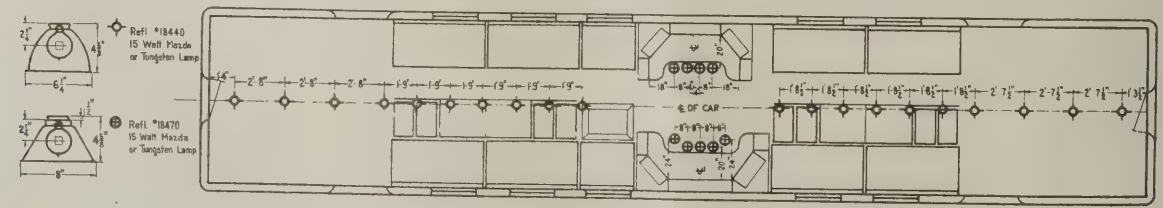


Fig. 12. Layout for 50 ft. Postal Car Using 15 Watt Mazda Lamps With Holophane D'Olier Aluminumized Metal Reflectors.
(All Units Mounted 7 ft. 6 ins. Above the Floor Measured to the Center of Lamp Filament.)

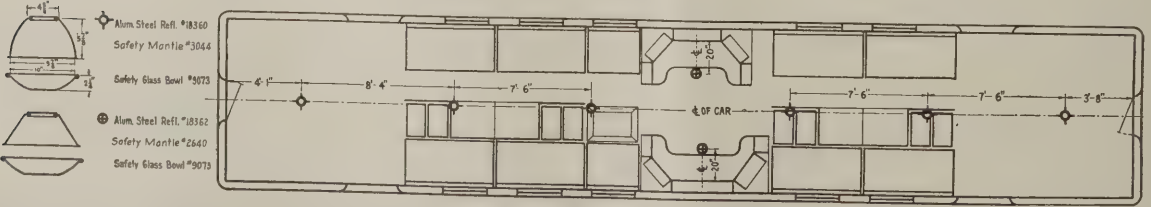


Fig. 13. Layout for 50 ft. Postal Car Using Pintsch Gas Mantle No. 3044 and No. 2640 With Holophane D'Olier Aluminumized Metal Reflectors.
(All Units Mounted 7 ft. 6 ins. Above the Floor Measured to the Center of the Mantle.)

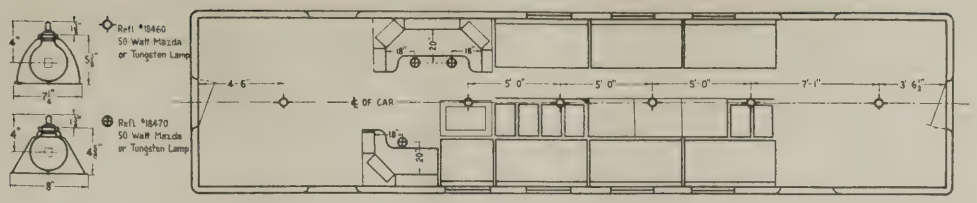


Fig. 14. Layout for 40 ft. Postal Car Using 50 Watt Mazda Lamps With Holophane D'Olier Aluminumized Metal Reflectors.
(All Units Mounted 7 ft. 6 ins. Above the Floor Measured to the Center of Lamp Filament.)

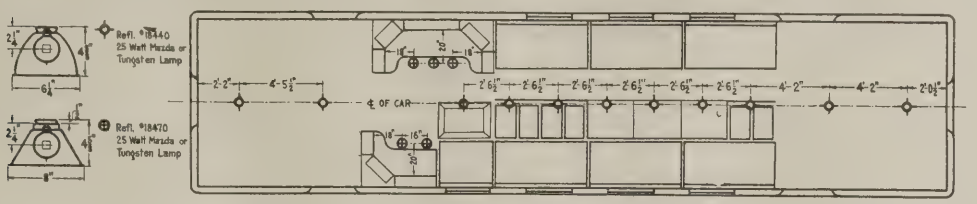


Fig. 15. Layout for 40 ft. Postal Car Using 25 Watt Mazda Lamps With Holophane D'Olier Aluminumized Metal Reflectors.
(All Units Mounted 7 ft. 6 ins. Above the Floor Measured to the Center of Lamp Filament.)

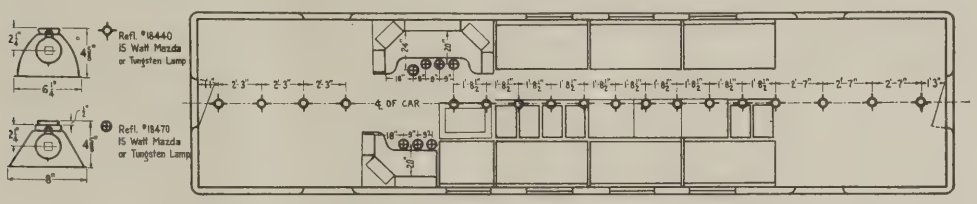


Fig. 16. Layout for 40 ft. Postal Car Using 15 Watt Mazda Lamps With Holophane D'Olier Aluminumized Metal Reflectors.
(All Units Mounted 7 ft. 6 ins. Above the Floor Measured to the Center of Lamp Filament.)

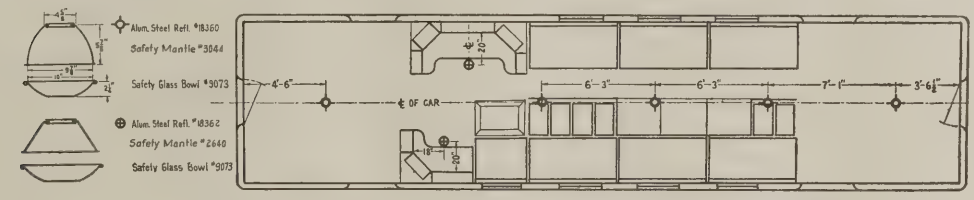


Fig. 17. Layout for 40 ft. Postal Car Using Pintsch Gas Mantle No. 3044 and No. 2640 With Holophane D'Olier Aluminumized Metal Reflectors.
(All Units Mounted 7 ft. 6 ins. Above the Floor Measured to the Center of Lamp Filament.)

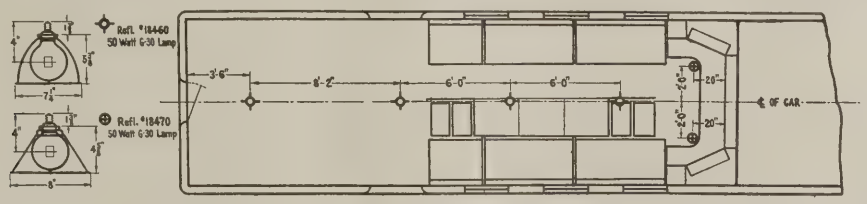


Fig. 18. Layout for Compartment Postal Car Using 50 Watt Mazda Lamps With Holophane D'Olier Aluminumized Metal Reflectors.
(All Units Mounted 7 ft. 6 ins. Above the Floor Measured to the Center of Lamp Filament.)

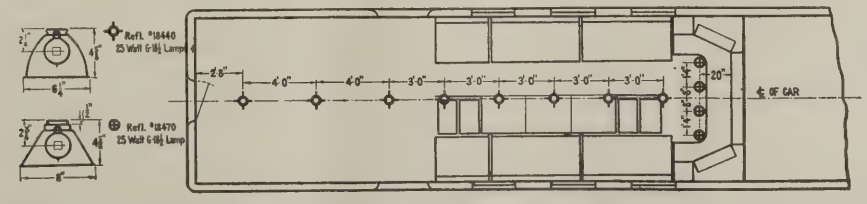


Fig. 19. Layout for Compartment Postal Car Using 25 Watt Mazda Lamps With Holophane D'Olier Aluminumized Metal Reflectors.
(All Units Mounted 7 ft. 6 ins. Above the Floor Measured to the Center of Lamp Filament.)

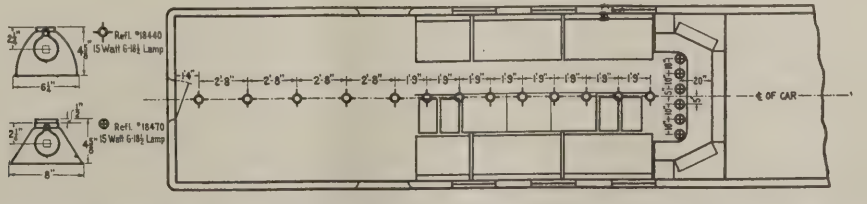


Fig. 20. Layout for Compartment Postal Car Using 15 Watt Mazda Lamps With Holophane D'Olier Aluminumized Metal Reflectors.
(All Units Mounted 7 ft. 6 ins. Above the Floor Measured to the Center of Lamp Filament.)

otherwise be the case. On the other hand, if spacing values were based on the most satisfactory type of reflector, all other types would be eliminated from consideration.

The writer believes that the problem of supplying railway engineers and car builders with exact installation data, requiring no specialized illumination knowledge to interpret, will prove to be a relatively simple one. It will be an easy matter to provide exact installation layouts for the two or three most satisfactory types of reflector equipment. Such layouts will doubtless meet all necessities, as it is highly improbable that any railroad will care to use such types of reflectors as have been found, in the thorough research which has been made into postal car lighting, to be the least suitable for this service.

In another part of this issue is published a series of installation layouts applying to the aluminumized metal reflector type.

Screening Angle.

The postal clerk at work in the sack rack portion of the car has frequent occasion to turn round in order to deposit postal matter in the bags behind him. When he does so turn around and glances, perhaps, up or down the car, his eyes should be protected from any danger of seeing the bare lamp filament or the bare mantle. For this reason, the specifications provide that no portion of the bare lamp filament or the bare mantle shall be visible to the eye when the unit is observed at an angle of 70° or greater from the nadir. The general use of wing cases makes such specifications unnecessary as applying to letter case units, since the case itself screens the unit from the vision of one working in the sack rack portion of the car, while the location of the unit itself places it outside of the field of vision of one working at the letter case.

It was considered sufficient to limit the imperative portion of the specifications regarding screening to the provision that the bare lamp filament or bare mantle should not be visible when the unit is observed at an angle of 70° or greater from the nadir. It will be, however, evident that an objectionable condition will exist if the lower part of the reflector appears brilliantly illuminated, when the postal clerk glances up or down the car. For this reason, the specifications state that, in general, light units are preferred which emit no light or only a small amount of light between the angles of 50° and 100° from the nadir. Reference to Figs. 2 and 3 show that the requirements of the service demand very little light above the 50° angle. The maximum possible reduction in the light emitted above 50° need not, therefore, interfere in the least with obtaining the proper illumination intensity and uniformity results.

Research work has established to a high degree of probability that all light entering the eye within 25° with the line of vision reduces the capacity of the eye to see. If, therefore, it be assumed that the line of vision is never raised above the horizontal, a unit giving no flux above 65° could not directly decrease the capacity of the eye to see (note 90° — 25° = 65°). If it be assumed that the line of vision may sometimes be raised 15° above the horizontal, the light unit should give as little flux as possible above the angle of 50°, in order to leave the eye in a condition of maximum efficiency. These considerations explain the preference expressed in the specifications for a unit emitting as little light as possible above the 50° angle, and emphasize the importance of regarding the preference thus expressed.

The aluminumized metal reflector, the porcelain enameled metal reflector, and the mirrored glass reflector have the advantage that they transmit no light whatsoever. It is, therefore, more completely possible with these types of reflectors to reduce the light emitted at angles above 50°. The lack of diffuseness of illumination, later to be discussed, which characterizes the porcelain enameled and mirrored reflectors, does not characterize the aluminumized metal reflector. This fact is here mentioned in order that, when the relative qualities of different types of reflectors are later discussed in this article, the advantage of the aluminumized metal reflector in throwing little or no light into the eyes of the postal clerk when he looks up or down the car will not be forgotten.

Discrimination Between Different Classes of Reflector.

It has for some time been realized by illuminating engineers that the intensity of illumination required for efficient visual work varies according to several factors,—notably according to the diffuseness of the illumination provided, the nature of the light-giving or light-receiving objects throughout the entire field of vision, and the character of the work itself. One of the most important of these determining characteristics is that of the diffuseness of the illumination provided. The following explanation may not be amiss as explaining why a diffuse condition of illumination permits of satisfactory vision at a lower intensity than an illumination less diffuse.

When we look into a high-grade mirror, the mirror itself is invisible, and we see only the objects reflected by it. Let us now suppose that the paper which we are reading (or the letters which the postal clerk is sorting) is thickly strewn with minute mirror surfaces. These mirror surfaces will themselves be invisible, but will each reflect a minute portion of the surroundings in the room. If they happen to reflect brilliant light sources, they will produce an effect similar in kind, though of course lesser in degree, to that occurring when one looks directly at the light sources themselves. We all realize that looking directly at bright light sources materially reduces the capacity of the eye to see. Hence it follows that the presence of such numerous minute mirror surfaces on our paper may appreciably cut down the capacity of the eye to see. If all the illumination on our paper is derived from intensely bright light sources instead of by indirect lighting from the ceiling, or instead of from larger and less brilliant light sources, this effect in cutting down the capacity of the eye to see may become very considerable. The fact that such minute reflections occur almost directly along the line of vision very materially, of course, increases the effect produced by them.

Now such mirror-like or specularly reflecting surfaces are present in the case of practically all papers. If the paper is entirely unglazed, the amount of such specularly reflecting points is tremendously reduced; but there is convincing evidence that such minute specular reflecting surfaces are present in practically all cases, even when they cannot be detected by mere observation.

In the case of a mirrored or silvered-glass reflector, the illumination produced by it is derived from the brilliant lamp filament itself or from relatively small portions of the reflector which are brilliantly illuminated. In technical terms, therefore, the illumination given by such a light unit is very non-diffuse. When our paper, which we will remember has at least a considerable number of the minute specularly reflecting surfaces referred to above, is read under such illumination, the small surfaces reflect into the eye

images of the brilliant lamp filament or the brilliant spots on the reflector surface, and the capacity of the eye to see is materially reduced. To off-set this, we have to increase the intensity of illumination provided. As a matter of fact, such increase in intensity of illumination does not entirely compensate for the influence of the specularly reflected light. It does permit us for the moment to see equally well; but the conditions are such as to produce a greater degree of fatigue than would be the case with a more diffuse illumination and a correspondingly lower intensity of illumination.

In the case of a clear prismatic reflector, the reflecting surfaces are rather brilliantly illuminated, though not so brilliant as in the case of the mirrored reflector. The tendency of the reflected light from the prismatic reflector is therefore such as to produce an illumination rather non-diffuse in character. The prismatic reflector, however, permits a considerable amount of light to pass through it and fall upon the ceiling, the light being thence reflected downward. Now the effect of light reflected from the ceiling is to produce an illumination highly diffuse in character. The net effect, therefore, of the prismatic reflector is to produce an illumination moderately diffuse in character.

Light density or medium density opal reflectors produce an illumination similar in the matter of diffuseness to that of the prismatic reflector. Such opal reflectors, if at all glazed inside, show on the reflecting surface brilliant lines which are the images of the lamp filament. These comparatively brilliant reflections of the lamp filament tend to produce an illumination non-diffuse in character. On the other hand, the effect of the light transmitted through the reflector and reflected from the ceiling is to produce a diffuse illumination. The net effect as to diffuseness of illumination is, therefore, very similar to that of the prismatic reflector—probably slightly more diffuse than the clear prismatic reflector and undoubtedly less diffuse than the satin-finished prismatic reflector.

In the case of the porcelain enameled metal reflector, the reflection from the enamel particles themselves is, of course, diffuse in character. Such porcelain enameled reflectors, however, always have a considerable glaze, and hence show well-defined and comparatively brilliant images of the filament. On the other hand, they transmit no light toward the ceiling, so that there is no ceiling reflection to increase the diffuseness of the illumination produced. The net effect, therefore, of the porcelain enameled metal reflector is to give an illumination very considerably less diffuse than that given by a prismatic or opal reflector, though more diffuse than that given by the mirrored reflector.

In the case of an aluminumized metal reflector, the entire interior surface is illuminated to an approximately uniform brilliancy. There are no images whatsoever of the lamp filament. This tends to produce an illumination moderately diffuse in character. On the other hand, there is no light transmitted to the ceiling. The net effect of the aluminumized metal reflector is, therefore, to give an illumination about equal in diffuseness to the clear prismatic or to the opal reflector with glazed interior surface, and somewhat less diffuse than the satin-finished prismatic or depolished opal.

Indirect lighting, of course, gives an illumination of the maximum diffuseness which we know how to produce in the present state of the art. It, therefore, produces an illumination under which adequate vision can be accomplished at a lower intensity and with less fatigue than with any direct lighting system.

The preceding paragraph applies only to the truly indirect lighting system. Several so-called indirect or semi-indirect systems are on the market which in no sense of the word deserve to be styled as such. The essential feature of the indirect lighting system is not that the light ray starts first in an upward course and is then reflected in the downward direction, nor in that the lamp filament is concealed from view. The essential feature of the indirect lighting system is that a large, diffusely-reflecting surface, such as the ceiling, is illuminated to a low brilliancy. All the advantages of the indirect system arise from this feature. Any so-called indirect system, therefore, which does not embody the above feature is improperly styled.

The above paragraphs set forth the theoretical analysis of the different types of light unit relative to the diffuseness of illumination given by them. Extensive test data taken in connection with a recent research on postal car lighting strongly substantiates the above analysis. This test data indicates that, where the mirrored reflector, porcelain enameled metal reflector, or the heavy density opal reflector with glazed reflecting finish is used, the illumination required for adequate vision is about 23 per cent higher than that required where the prismatic reflector, medium or light density opal reflector, or aluminumized metal reflector is employed. It was this test data, corroborated by the limited experimental data previously available on this subject and by the theoretical analysis of the case, that led to basing the intensity requirements of the specifications on the mirrored, the porcelain enameled, and the heavy density opal reflectors, and giving a bonus of 20 per cent for other types of direct lighting unit, and a 40 per cent bonus to the indirect lighting system.

Comparative Merits of Different Types of Reflector.

It is believed that the four main qualities, upon which the suitability of a reflector for postal car lighting surface must be judged, are (a) relative effect in minimizing eye-strain, (b) relative efficiency, (c) relative amount of maintenance attention required, and (d) relative liability to breakage. In all these qualities, except that regarding maintenance, the aluminumized metal reflector stands at or near the head of the list.

Of course, the four factors listed above are not of equal importance. Effect on eye, efficiency, and cleaning considerations are unquestionably more important than the question of breakage. Effect on eye and efficiency seem to the writer more important than either maintenance or breakage considerations. On any relative weighting values of the above factors which could be justified as reasonable, the aluminumized metal reflector will be found to stand first as the most satisfactory type.

As has been previously pointed out in this article, it is practically impossible to meet the requirements of the specifications at the letter case except by the use of the aluminumized metal reflector, the prismatic reflector, or the mirrored reflector.

The aluminumized reflector is about 10 per cent more efficient than the porcelain enameled metal reflector, due to the more diffuse character of the illumination given by it. The specifications give the aluminumized reflector an advantage of 20 per cent over the porcelain enameled reflector. The aluminumized metal reflector has therefore a total advantage of about 30 per cent over the porcelain enameled reflector. In order, therefore, to meet the specifications, the porcelain enameled reflector must be spaced closer than the aluminumized reflector in the sack rack and storage

portions of the car—in short, it is impracticable, if not impossible to meet the provisions of the specifications at the letter case, if a porcelain enameled reflector be used, while the use of this type in the body of the car requires, in a 60 ft. car, an increase of from 50 watts to 100 watts above that required if the aluminumized type of reflector were employed.

The writer believes the above considerations will lead to the practically universal adoption of the aluminumized reflector type in postal car lighting.

The one objection to the aluminumized metal type is that it requires careful attention as to maintenance. Under average conditions of service, the reflector should be taken down from the socket and thoroughly cleaned about once every four months. Of course, the frequency which such thorough cleanings are required will vary considerably, under various conditions of service, from the average values above given. In addition to the above thorough cleanings, the aluminumized reflector should be wiped out with waste or a soft cloth, but without removing from the socket, at least once a month.

In cleaning the aluminumized metal reflector, the reflector should be washed in soapy water with a soft cloth, after which it should be thoroughly rinsed in clean water and wiped dry with a soft cloth. If these cleaning directions are followed, the aluminumized surface of any good make of this type of reflector will last for many years. The aluminumized metal type of reflector is as adaptable to Pintsch gas lighting as to electric lighting service. Such aluminumized metal reflectors for Pintsch gas lighting have already been developed. It may be stated in passing that the specified lighting requirements at the letter case cannot be met when the well-known Corona type of reflecting and diffusing globe is employed.

Required Intensities.

Extensive test data, taken in connection with recent researches on postal car lighting, has shown that approximately 2.25 f. c. is the minimum intensity satisfactory for continuous close work in this class of service. This figure of 2.25 f. c. represents the average of all direct lighting units tested. The mirrored, porcelain enameled, and heavy density opal reflectors required slightly less than 2.50 f. c., while the other types of direct lighting unit required about 2.00 f. c. It was decided, therefore, in order to be on the safe side, to require, for points in the car where long-continued close work was to be performed, a minimum service intensity of 2.25 f. c. when the more satisfactory types of direct lighting unit were used. Since the specifications were to be based on the mirrored, porcelain enameled, or heavy density opal types, and a 20 per cent bonus allowed for the more satisfactory types, 2.80 f. c. became the specified minimum intensity for points in the car where continued work has to be performed.

In the storage portion of the car, close work has to occasionally be performed for comparatively brief periods. In preparing the specifications, the writer's judgment was accepted that 1.20 f. c. with the more satisfactory types of direct lighting unit, or 1.50 f. c. with the less satisfactory types of unit, was an adequate minimum for these conditions of service.

At the mouth of the bags, and on the face of the letter case, the visual work performed is continued for comparatively long periods, but this visual work is not close in character. It was the writer's recommendation that 1.00 f. c. with the more satisfactory types of direct lighting system, or 1.25 f. c. with the less satisfactory types, was a satisfactory minimum service intensity. This recommendation was adopted in preparing the specifications, with the exception that the specified minimum at mouth of the bags was increased to 1.50 f. c., since it was found that this could be done without entailing any hardships. In other words, the installation which would meet the specified requirements down the center of the car would, of practical necessity, meet the value finally decided upon and employed in the specifications for illumination at the mouth of the bags.

The determinations of minimum service intensities required was made by day in a darkened postal car. In other words, the subjects came into the car from the daylight outside, and hence with their eyes adapted to daylight conditions. This tended to make the test show a higher minimum value than would have been the case if the tests had been run entirely by night. On the other hand, it might reasonably be supposed that the vibration of the running car would make necessary a higher intensity of illumination than would be sufficient in a stationary car. Continuous test by a crew of eight on an all-night run showed that the effect of the test having been made in a darkened car by day more than off-set whatever disadvantages might arise from the vibration of the moving car. In other words, the intensities derived as above recorded are believed to be sufficiently adequate for the conditions of service in the running car throughout the night run.

Maximum and Minimum Densities.

To the illuminating engineer it will be a matter of interest to note that the new postal car lighting specifications contain no provisions as to required uniformity of illumination. Instead, the specifications provide maximum and minimum limits within which the intensity values must come. The writer believes that the substitution of a maximum and minimum specification for a uniformity specification is wholly desirable practice, and may well be extended to other fields of service than postal car lighting. Lack of uniformity in illumination is not to any important degree objectionable, providing the changes in intensity are not too abrupt, and providing further that the minimum value does not fall below, nor the maximum value exceed certain proper limits.

The writer's view-point in this particular will be made clear by a specific instance. Let us suppose a given room to be illuminated with practically perfect uniformity except that one portion of the room, comprising, say, one-sixth of the entire area, is under-illuminated or over-illuminated. Since the uniformity figure represents an average of all points in the room, the uniformity value for the particular instance assumed would appear highly satisfactory; yet the actual results would be much less satisfactory than would be the case if the room were illuminated to a lesser uniformity, but with no considerable area exceeding proper maximum and minimum limits.

As far as the question of abrupt changes in illumination intensity is concerned, this consideration is more theoretical than practical. With such types of light unit as are generally employed, it is highly unlikely that abrupt changes in illumination intensity will be made unless the production of such abrupt changes is intentionally sought for.

In short, it is the writer's contention that uniformity specifications have little meaning until maximum and minimum specifications are also included and where such maximum and minimum specifications are in-

cluded, the uniformity specification has a negligible value and meaning.

Service Depreciation Allowances.

The best car lighting maintenance to be found in American railroad practice at the present date represents a service depreciation of about 40 per cent. That is to say, taking any car in service at random, the average illumination values will not be found under service conditions to have dropped more than 40 per cent below the initial installation value where the reflectors were clean, the lamps new, the head-lining fresh, and the battery at exactly correct voltage. This statement of course excepts those occasional service conditions which are regularly counted as complete light failures.

Average railroad practice of the present time probably represents a service depreciation factor of 50 per cent. The 40 per cent value referred to above applies only to the best of present practice.

In view of the above facts, the initial installation values of the specifications were made such that a 40 per cent deterioration from the initial intensity would just bring the intensity value to the amount previously determined as the minimum permissible service intensity. It will, of course, be realized that the majority of railroads, whose present practice in car lighting maintenance does not insure the attainment of a service depreciation factor as low as 40 per cent, must either put in an initial installation giving in excess of the installation values of the specifications or else must improve their maintenance practice up to a point equal to that of the foremost railway practice of the present time.

General Conclusions.

The new postal car lighting specifications, and the very complete technical data on postal car lighting at present available, have brought the subject of postal car lighting to the point of a quite definitely established standard. The data available has shown that the aluminumized metal reflector better meets, by a very considerable degree, the requirements of the service than any other type of reflector. The data further shows that the 50 watt lamp, the use of which is favored by many practical considerations, will give results equally as satisfactory as those obtained with the smaller sizes of lamps. Again, it was shown that, providing the proper type of reflector is employed, the Pintsch gas system will give equally as satisfactory illumination results as the incandescent electric system. The data has established with great exactness a standard arrangement of light units, thus obviating a considerable source of annoyance to railway engineers, car builders and railway mail service executives. Finally the test data has definitely established that adequate lighting of postal cars can be accomplished without entailing upon the railroad interests any burdensome requirements whatever, either in increased energy consumption or in increased cost of installation. The formal issuance by the Post Office Department of the new specifications obviously implies concurrence in the above conclusions and a hearty desire to impose no burdens whatever upon the railway interests other than those made necessary by the necessity of insuring adequate lighting service.

It is the earnest belief of the writer that the experience of the future in applying the new postal car lighting specifications to postal car lighting practice will generally call forth from railway executives a deserved appreciation of the broad-mindedness and far-sightedness of those railway engineers and railway mail service executives whose co-operation has served to make the issuance of these specifications possible.

THE PIONEER TRAIN LIGHTING ASSOCIATION OF ST. LOUIS.

As announced in our last issue, the Pioneer Train Lighting Association of St. Louis is conducting a "Questions and Answers," department in connection with its monthly meetings, and in order that all interested may receive the benefit of this information we will publish in each month's issue the questions and answers received.

Questions and answers received at the meeting are as follows:

Question 1. Is it possible to take two negative elements changing one to positive and have an operating battery?

Answer—Take two negative elements, put them together in a tank with electrolyte and charge them. The current flowing from the positive through the electrolyte to the negative will produce a chemical action in the plate connected up as positive, changing the active material (formerly spongy lead) to lead peroxide. This peroxide is the active material of the positive plate and after all the spongy lead has been converted to peroxide the plate is a regular positive plate.

Question 2. Should a pilot lamp for axle generator be fused? If so, why?

Answer:—Pilot lamps are generally connected across the positive field and negative generator. Although some times they are connected the positive machine and positive field. It is a good policy to use a receptacle so that a fuse can be placed in the pilot lamp circuit. In certain cases where pilot lamps have not been fused this has been the cause of fire due to short circuited pilot lamp with an over rated machine fuse.

Question 3. Is it good practice to wash battery boxes after flushing battery?

Answer:—Different conditions require different practice. With the old type unsealed batteries which slopped a good deal, dust and sand which comes through the vent holes in battery boxes mixes with the acid and in time form spongy coatings over the tanks. With the sealed type battery dust and sand comes through the vent holes and often times can be brushed out dry. However, it is a good plan to wash out battery boxes with water for the reason that it weakens the acid that comes in contact with the wood so that it does not eat the wood and does not destroy battery connections and roller brackets on battery parts. Allow the battery box to dry out thoroughly after washing and flushing. This practice will eliminate grounded battery.

"ELECTION," NEW HOUSE ORGAN OF CENTRAL ELECTRIC CO.

This is the title of the new house organ of the Central Electric Company, first issue of which appeared in February, 1913. This first issue is a worthy little publication and it is far different from the loose leaf catalog proposition of so many house organs. It is a miniature magazine, well edited, and contains some interesting articles. The February issue contains a complete description of the new C. B. & Q. Ry. office building. This is one of the biggest installations for indirect lighting in the country.

SHOP SECTION
EDITED BY
GEO. W. CRAVENS

Motor Talk No. 5

ALTERNATING CURRENT MOTORS.

The differences and similarities between direct current and alternating current motors are frequently misunderstood, whereas the matter is really comparatively simple. We hear a great deal about reactance, impedance, inductance, capacity and the other weird phenomena of alternating current circuits and apparatus, but after all they are as harmless as any other bugbears. So let us put on our glasses and look at alternating current motors fearlessly for a little while and see just what they are like.

What is an alternating current, anyway, and wherein does it differ from a direct current? Perhaps the answer to that question will help a little. An alternating current is one which flows out from a generator, around the circuit in one direction and back to the generator, and then reverses and flows back through the circuit, in the opposite direction, and to the generator again. In order to do this it is evident that, starting at zero value, it must gradually (but rapidly) increase to its maximum (highest) value in one direction before it will do much work, and then drop to zero again before it can reverse and flow back again in the other direction, and do more work.

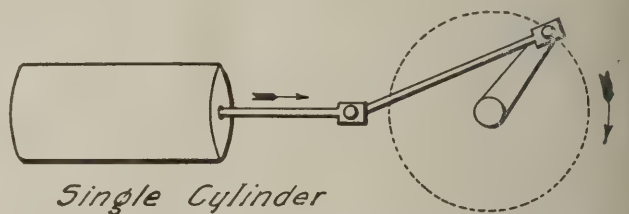
A direct or continuous current is one which flows always from the generator out through the circuit, in one direction, and to the generator. There is no reversal or alternation of the direction of flow, nor is there any change of value. This is due to the fact that the commutator on the direct current machine only allows that current to flow which is in the right direction, and chokes back or cuts off that tending to flow in the opposite direction.

The current generated inside a dynamo is always alternating in character, due to the passing of the armature windings through the magnetic fields of north and south poles (positive and negative) alternatively, and that is why a commutator must be attached to rectify or control the flow of current.

Before taking up the principal characteristics of a. c. motors generally, let us first consider the alternating current itself a little more in detail and be sure we understand that. Did you ever watch a steam engine working, and see how the piston rod is forced in and out by the steam? And how the direction of rotation of the crank shaft and driving wheels is the same when the piston-rod is moving out as it is when the rod is moving back again? That is because suitable means are provided in the cranks and connecting rods to transform the movement of the piston into a direct or continuous movement of the shaft in one direction. The action of an a. c. motor is very similar.

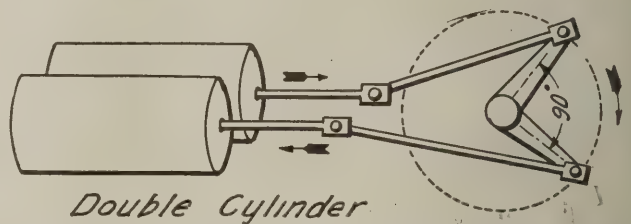
Referring to Figs. 23, 24, 25, we can see the similarity between three well known kinds of steam engines and the three principal kinds of a. c. machines, single-phase, 2-phase or quarter-phase and 3-phase. Fig. 23 indicates a single cylinder engine, and compares with the single-phase system because work is done first in one direction and then in the other, with zero points at the instant of change or crossing center, and yet the direction of rotation of the shaft or driving member is always in the same direction, as with a motor.

Fig. 24 shows a 2-cylinder engine, and compares with the 2-phase system because there are two sets of impulses for each revolution or cycle (two each way). Since the cranks are set at right angles (90°), one piston (impulse) is doing its maximum work while the other is at zero (passing center line). The effect is of an almost continuous pressure in the direction of rotation, as with a 2-phase motor, in spite of the reversal of direction of travel of the energy (steam in the cylinders.)



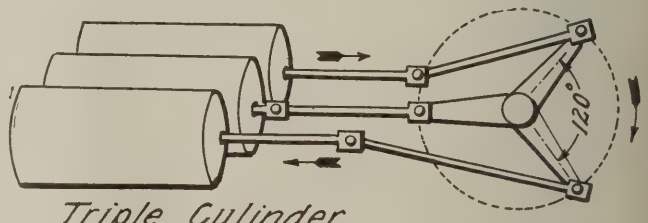
Single Cylinder
2 impulses per revolution – 1 out & 1 in
Single phase motor

Fig. 23.



Double Cylinder
4 impulses per revolution – 2 out & 2 in
Two phase or quarter phase motor

Fig. 24.



Triple Cylinder
6 impulses per revolution – 3 out & 3 in
3 phase motor

Fig. 25.

With a 3-cylinder engine, Fig. 25, we get a condition similar to that in the 3-phase system. Here we have 3 cranks set at 120° apart; one moving out, a second just passing center (zero pressure) and the third moving back. In a 3-phase alternating current electric system we have three sets of impulses; one increasing in value in one direction, a second passing through the zero point and third falling off in value in the reverse direction. During each cycle of operation we get 6 impulses or pressure changes, 3 in each direction.

The principal parts of an alternating current motor are the stator or stationary part (usually called the field or frame) and the rotor or rotating part (usually called the armature). So far, our description might apply to any sort of motor. But, in this particular case there is no electrical connection between the armature and field circuits, whereas with direct current motors the field windings must be energized from the same source as the armature windings.

In other words, an alternating current motor is like a transformer, and the current in the primary or stator coils sets up or induces a current in the secondary or rotor coils (through the action of the magnetism), this induced current reacting on the field and causing the armature to revolve. This same effect is present in transformers, and the tendency for the coils to move in relation to each other sometimes causes trouble. In fact, coils have been known to jump right out through the casing of transformers when not properly fastened.

One of the principal points of difference between direct and alternating current motors lies in the fields. With direct current (d. c.) motors the field windings are energized always in the same direction, and the poles are always either north or south (positive or negative), whereas with alternating current (a. c.) motors the field windings are alternately energized by currents in opposite directions, and consequently are continually changing or alternating the polarity.

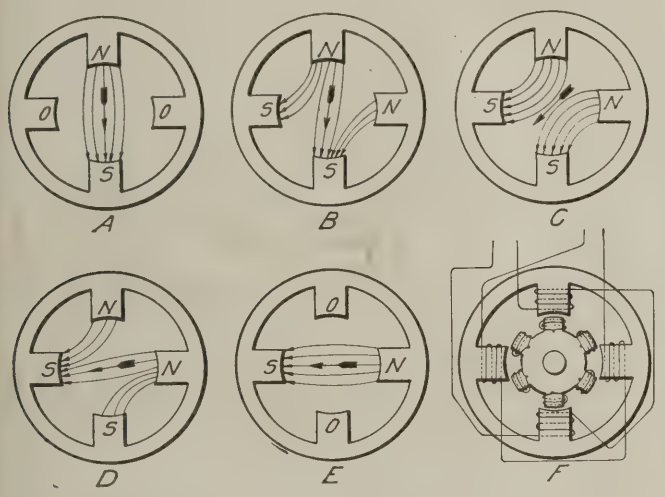


Fig. 26. Rotation of Magnetic Field.

With d. c. motors the commutator allows the line current to flow into the armature coils in such a way that the effect of the continuous magnetic field will cause the armature to rotate in the proper direction. Since a. c. motors (with one exception) have no commutators, and since the field polarity is continually changing, some other provision must be made to cause the armature to rotate and in the proper direction. Unless this is done the tendency would be for the armature to rock back and forth as the field changed, and it would be useless as a means for driving machinery.

In order to take advantage of the changing directions of flow of current, and shifting polarities of motor fields, a. c. motor windings are placed on the fields in such a way that the changes of polarity take place regularly and always in the same direction. By doing this, a "rotating field" is set up which causes a series of polarity changes to move around the frame always in the same direction, and since the armature windings also have currents induced in them which form poles in the armature core, there is a reaction set up which causes the armature to turn in the same direction as the "rotating field." It must be understood that the frame does not move, but simply the magnetic field created by the current flowing in the windings of the stator. That moves around or changes its position in the frame.

Reference to Fig. 26, letters A to E, will show how this takes place. These show, as diagrams, a 2-phase motor with the armature represented as a two-pole armature or compass needle. At the moment of starting, let us assume the upper pole to be a north or positive pole. The field windings are placed in such a way that the opposite pole is a south or negative pole at the same instant, and is energized by the same phase or line of the system. Since the energy in one phase of a 2-phase system is at zero when the energy in the other is at maximum, the two side poles in this example will be dead for an instant because their windings are connected to the other phase.

Owing to the constantly changing values in the two phases, first increasing from zero to maximum in one direction and then falling off, passing through zero and then rising to maximum in the opposite direction, in each phase (the same as the steam pressures during each stroke of each piston in a 2-cylinder engine), there will be a gradual shifting or rotating of the magnetic field in the frame of the motor as indicated by the figures. As the field changes, the needle or armature will also rotate in order to follow the field around.

Fig. 26-F shows a six pole armature in place with the windings around the pole pieces. Each coil of the armature is shown short circuited on itself as it is customary to make each one a closed circuit and independent of the others, as will be explained later. Regarding the number of poles and the arrangement of the coils it is evident that if a motor is made with a small number of poles, each pole with a single coil, that the spaces between the poles will be large. Whereas, if we have a large enough number of poles each of them must be small, in order to get them in a frame of reasonable size, and the spaces between also become so small that we call them slots. Then, also, the windings or field coils become small and are distributed around the frame in the slots in such a way that magnetic poles are formed embracing several slots. The same principle applies to armatures, and this practice explains another great difference between a. c. and d. c. motors.

In future articles of this series we will take up the various types of a. c. motors in detail and explain their actions and characteristics, in the hope that some of the mystery surrounding them may be dispelled.

BATTERY-CHARGING MOTOR-GENERATOR SETS FOR RAILWAY WORK.

Bulletin No. 4085, just issued by the General Electric Company, describes more or less briefly that company's battery-charging motor-generator sets for railway work. The bulletin should be of service to railway men.

NEW SANGAMO METER BULLETIN.

The Sangamo Electric Co., Springfield, Ill., are distributing Bulletin No. 34, descriptive of their complete lines of single-phase and poly-phase induction watt-hour meters. This bulletin is one of the most complete which has as yet been issued, and will be appreciated by central station meter superintendents desiring complete information on the latest metering developments.

LESSON No. 14

Head-end System

Curtis Turbo-Generator Set.

The 25-k.w. Curtis Turbo-Generator set has been very extensively adopted as the generating unit for head-end trains. Head-end electricians are more or less familiar with the operating features of this set, and they have been taken up to some extent in the past lessons of this course, so we will confine ourselves in this lesson to a study of steam turbine construction and the principles underlying its operation.

The steam turbine operates on very much the same principle as the ordinary windmill. The steam blowing at an extremely high velocity against the buckets mounted on the outer edge of the turbine wheel actually blows it around, causing the turbine to rotate at a very high speed. The steam is first emitted through the throat. Here the steam expands from full pressure down to approximately atmospheric pressure, and the pressure energy of the steam before entering the nozzles is here used in giving the steam the enormous velocity of about 2,500 ft. per second. This blast of steam strikes the rotating blades at an angle

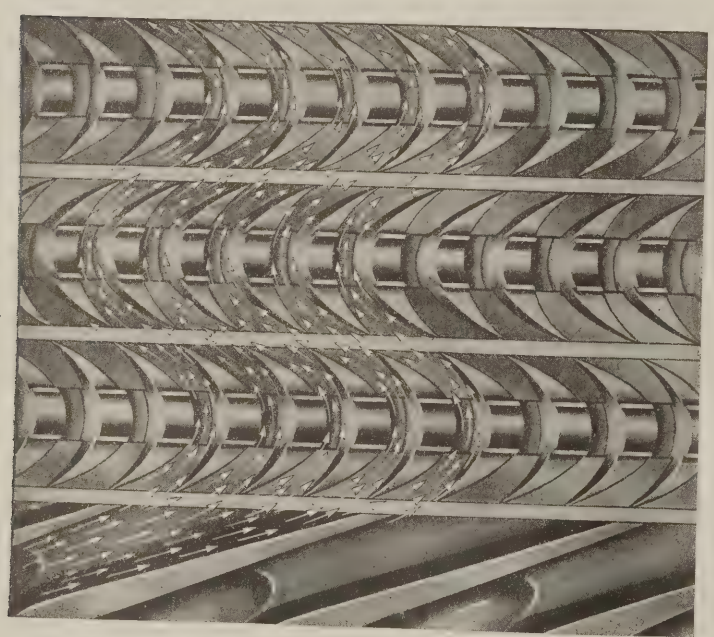


Fig. 71. Path of Steam Thru Moving and Stationary Buckets.

of about 20 degrees. The turbine is revolving at 3,600 r.p.m. (60 revolutions per second), which, with a 30-in. turbine wheel (8 ft. circumference), makes a bucket traveling speed of about 500 ft. per second, but the steam traveling at 2,500 ft. per second strikes the revolving buckets with considerable force. The surface of the buckets against which this steam strikes is curved so that in passing through the revolving bucket wheel the direction of motion of the steam is nearly reversed and on leaving the revolving buckets it is going in a nearly backward direction, as shown in Fig. 71. It here enters the set of stationary blades, where the direction of motion of the steam is again reversed so that upon leaving the stationary buckets the steam again strikes the revolving buckets of the second wheel in a nearly forward direction and again drives the turbine wheel forward with considerable force. In the 25-k.w. turbine there are three such rows of revolving buckets with two stationary rows between. As the steam passes through the successive revolving and stationary sets of buckets its speed is gradually lessened, due to the energy taken out of it in driving the revolving wheels and due to friction on the bucket surfaces.

Although the steam leaves the nozzle at a speed of practically 2,500 ft. per second, the bucket wheels are rotating in nearly the same direction at the speed of 500 ft. per second, so the velocity of the steam relative

Fig. 72. Turbine Wheel Showing Method of Assembling Buckets.

to the buckets would be but 2,000 ft. per second. Upon leaving the revolving buckets the steam is driven almost directly backward; so, although it leaves the bucket wheels with a speed of approximately 2,000 ft. per second relative to the revolving wheel, it is only traveling at a speed of 1,500 ft. per second relative to the first stationary set of buckets. Similarly upon entering the second set of revolving buckets the relative speed is again reduced 500 ft. per second, and on leaving these buckets is reduced another 500 ft. per second. This is not exactly true, for the steam both enters and leaves the buckets at an angle of about

20 to 35 degrees, so the direction of motion of the steam is not entirely reversed in the buckets; but for all practical purposes in explaining the operation of the turbine it is all right to consider it as above.

When the turbine is operating under ideal conditions the velocity relative to the buckets upon leaving the last set of revolving buckets will be just slightly greater than the peripheral speed of the buckets (500 ft. per second) and, as this is driven in a backward direction at a speed about equal to the forward motion of the bucket wheel, there will be just enough velocity of the steam relative to the stationary part of the turbine to cause the steam to slowly flow away from the last bucket into the exhaust chamber.

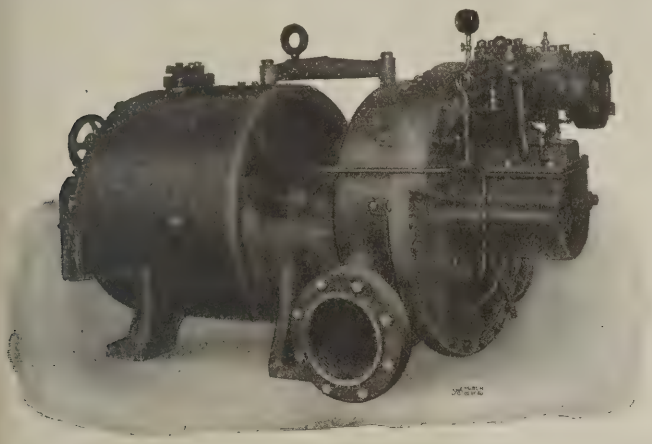


Fig. 73. Turbine and Generator Assembled.

When a river is shallow and narrow the current is rapid, but where the same river broadens out into a wide, deep channel the current is much slower. A similar condition exists in the steam turbine; when the steam first leaves the nozzle it engages but about 10 or 12 buckets. As it flows through each successive set of revolving and stationary buckets, however, its speed gradually falls off as explained above. The volume of the steam remains about the same, or, if anything, increases slightly, so the channel, or the number of bucket spaces through which this steam travels, must increase. At the last revolving wheel the steam is passing through nearly all of the bucket wheel spaces.

The force with which any heavy body strikes a stationary object varies with the square of the velocity. A train running at 60 miles an hour will strike four times the blow in a collision with a stationary object that the same train would if running at one-half the speed, or 30 miles an hour.

In the same manner the steam striking the turbine buckets at the speed of 2,000 ft. per second will deliver four times the push or torque to the turbine wheel that the same quantity of steam would when striking the buckets at 1,000 ft. per second. From this it is evident that the greatest part of the velocity energy is taken out of the steam in passing through the first row of buckets, and accordingly this row of buckets does most of the work in driving the turbine.

The buckets are made of a special alloy which is of very fine grain and non-rusting properties. The surfaces are highly polished so as to reduce the steam friction to a minimum. One end of the buckets which has been previously upset, is dove-tailed and this dove-tail fits into a groove in the face of the bucket wheel. These are mounted on the wheel as shown in Fig. 72, being inserted through a hole cut through the dove-tailing of the wheel. Dove-tailed spacing blocks are also inserted which keep the buckets in the proper position and the last spacing block is driven in the entry slot and piened over solid. A shroud or metal band is then wrapped around the tips of all the buckets, and the bucket ends inserted through it and piened over solid. This holds all the blades rigidly in place.

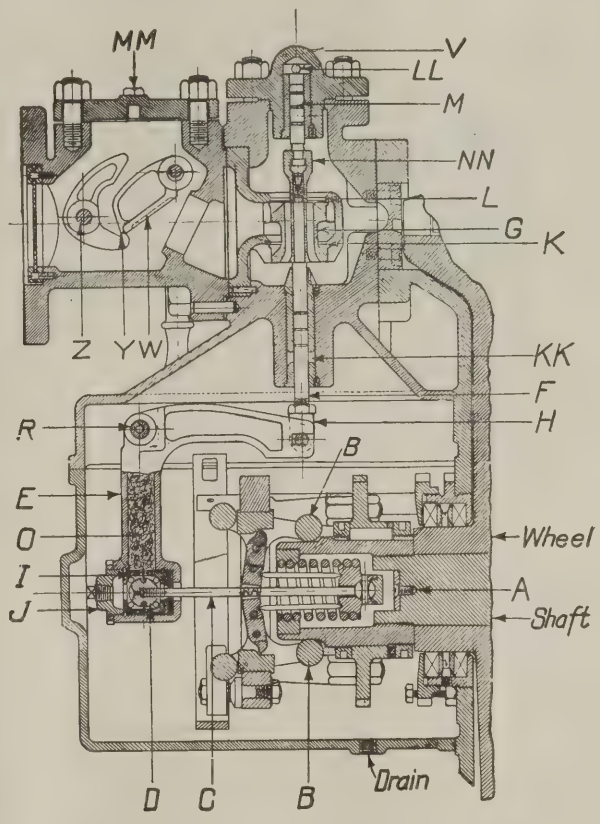


Fig. 74. Section Thru Governor and Valve.

There is a certain amount of axial or end play allowed for the revolving element of the turbine but this is limited by alternate steel and phosphor bronze thrust washer located on each end of the main lining. The inner washers are held stationary on the lining while the remaining washers revolve on the shaft. These washers are lubricated by oil carried along the shaft.

The Governor.

As the load on the turbine is increased there is a tendency to slow down in speed, but wherever a slight reduction in speed occurs the governor, which is known as the "throttling" type, opens up the balanced piston valve and allows more steam at a slightly higher pressure to enter the nozzle. There is then an increase in both the amount and velocity of the steam striking the bucket wheels, so that the power delivered by the turbine will be increased to meet the increase in load applied to it.

The details of the governor are shown in the accompanying diagram of Fig. 74, the rotating element on the end of the turbine shaft being shown in the two views, Figs. 75 and 76. The entire governor apparatus, as shown in Figs. 75 and 76, is fastened rigidly to the turbine shaft and revolves with it. There are two sets of governor weights shown as vertical cylinders in Fig. 74 and shown as small circular sections in the diagram Fig. 75. Both weights of each set are mounted on the same frame and pivoted as shown in Fig. 75, one weight, however, has a somewhat longer lever arm than the other. When the

turbine is revolving each of these unbalanced weights tends to fly outward, but the weights (B, B) in Fig. 74 having a longer lever arm from the common pivot than the other two, acts with more force, so that if the speed of the turbine goes above normal (3,600 r.p.m.) weights (B, B) will fly outward and by causing this weight frame to turn about its pivot will force the

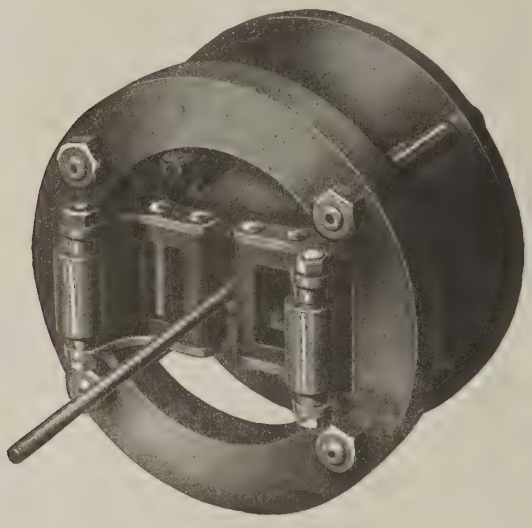


Fig. 75. Shaft Governor.

other weights more near the center of the axis, and at the same time will cause the third leg of the governor weight frame to press against the governor spring. This causes the shaft (C) to be drawn into the governor head and the ball on the end of it revolving in the stationary socket of the arm (O) draws this to the right, which acting about its pivot (R) presses upward on the valve piston (H) and raising the balanced piston valve (G), shuts off the supply of steam somewhat and reduces speed to normal value. Similarly, if the speed of the turbine falls below normal, the centrifugal force of the weights (B, B) will be lessened and they will move more toward the center of the shaft to the position more nearly as shown in Fig. 74. This will allow the governor spring to force

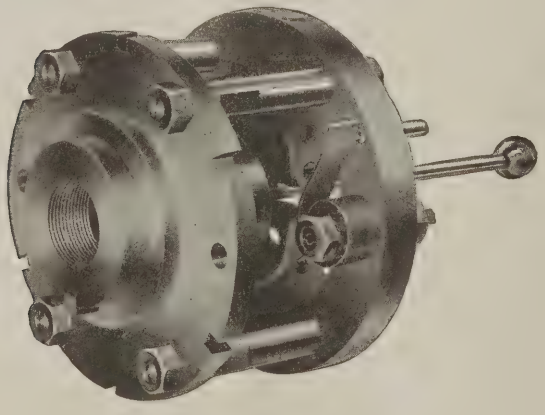


Fig. 76. Emergency Governor.

the shaft (C) and the ball and socket member (O) to the left, which drops the piston valve and allows more steam to enter the nozzle, bringing the speed up to normal.

By having two governor weights in each set, one of which is somewhat further from the pivot than the other, the governor is made very sensitive, for this unbalanced condition of the governor weights is greatly intensified by a slight increase or decrease in speed. On speed above normal the weights (B, B) are thrown further from the turbine shaft than under normal conditions, so that their centrifugal force will be much greater, but at the same time the other governor weights, (not lettered) against which the force of the weights (B, B) is balanced, will be forced nearer the turbine shaft and their centrifugal force will then be considerably lessened.

Emergency Stop.

In order to prevent the turbine from running away if for any reason the governor fails to work, an emergency stop is provided (which is set to work on 10 per cent above normal speed). Two small springs, one of which is shown mounted on the inside of governor disc, Fig. 76, fly outward slightly if the speed becomes excessive and strike a trigger arrangement which acts through a system of levers tripping the trigger lock (Y), Fig. 74, and allows the emergency valve (W) to close, instantaneously shutting off all steam from the turbine. After the trouble has been adjusted this emergency valve can be opened by hand and automatically resets itself.

The emergency springs should be tested occasionally. They are supposed to operate when the speed goes to 10 per cent above normal. This test can be made by pulling outward on the governor lever and inserting a ¼ inch threaded rod in the outer adjusting nut and allowing the turbine to speed up. This should be tried when the turbine is running light and the increase in speed determined by noting the percentage increase in voltage. The turbine may be shut down quickly by pulling on the emergency ring.

Fig. 77. Turbine Wheel and Armature Assembled.

The Generator.

Because of the extremely high speed the generator armature is of comparatively small diameter. There are but two poles and two sets of brushes. An auxiliary pole or inner pole is provided midway between the main poles for maintaining constant brush position and sparkless commutation. (See Lesson No. 2 —April, 1912.)

The armature core is built up of many laminations of soft iron which are press-fitted on the shaft and are held together by alloy heads which also support the end windings. The armature coils are inserted in slots cut into the laminated core and are securely held in place by phosphor bronze and steel binding wire. The commutator is much longer than an ordinary four-pole d. c. machine because of this generator having but two poles, the entire output of the generator must be taken through each set of brushes. In the ordinary four-pole machine having four sets of brushes only one half the generator output passes through any one set of brushes. The commutator bars are of hard drawn copper segments with mica insulation between. The segments are held in posi-

tion by means of nickel steel shrink rings insulated by mica and shrunk with such a pressure that the commutator brushes cannot become displaced under any condition of service. The wearing depth of the commutator is about half an inch.

Axle Lighting

THE ADAMS & WESTLAKE NEWBOLD SYSTEM.

The Newbold equipment manufactured by the Adams & Westlake Company, of Chicago, is one of the earlier types of car lighting equipment and has some features of design which are very different from other types of axle equipment. Like most other axle equipments, however, it regulates on the principle of reducing the generator field current by mechanically cutting in resistance in the generator field circuit as the train speed rises above cutting in speed.

The mechanical features of the regulator are very simple and are of special interest.

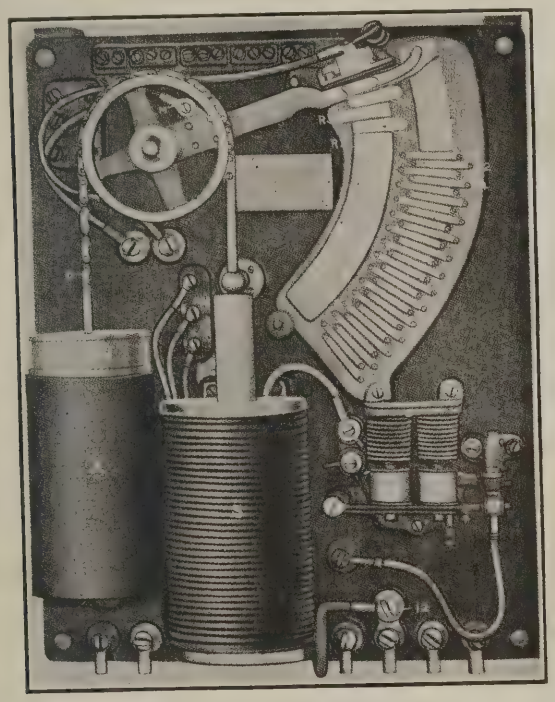


Fig. 78. Newbold Regulator.

The Regulator.

As shown in the wiring diagram Fig. 79, and the view of the regulator Fig. 78, the commutating segments of the generator field resistance are mounted on the panel in the form of an arc about the wheel (M) as a center. This wheel carries the contact arm (L) which sweeps across the contact segments, cutting in or out the generator field resistance as regulation becomes necessary. This wheel (M) is mounted on ball bearings and carries a flexible steel chain to one end of which is fastened the plunger of the main solenoid (I) and to the other end of which is fastened the dashpot plunger (W). When the equipment is operating at above cutting in speed, we have the pull of the weighted dashpot (W) balanced against the weight of the plunger (I) plus the magnetic pull on this plunger of the compound solenoid (S).

As the train speed rises the generator voltage will tend to rise proportionately, and this rise in voltage will tend to cause an increase in battery charging current flowing through the coil (S). An increase in current flowing through this coil will increase the magnetic pull on the plunger (I), and will cause the wheel (M) to revolve a trifle. The contact arm (I) rigidly fastened to this wheel then moves down; cutting in more resistance into the generator field and so cutting down the generator voltage and current to normal value. When the train speed decreases, the reverse operation occurs. The generator voltage and current tend to drop which decreases the magnetic pull on the plunger (I); this allows it to be pulled up by the weighted dashpot (W) acting on the opposite side of the wheel (M). As the arm (I) raises it cuts out some of the generator field resistance and causes the generator voltage to remain at normal value. In setting the regulator it is only necessary to add or remove some of the lead shot from the dashpot (W). The effect of this is easily understood,

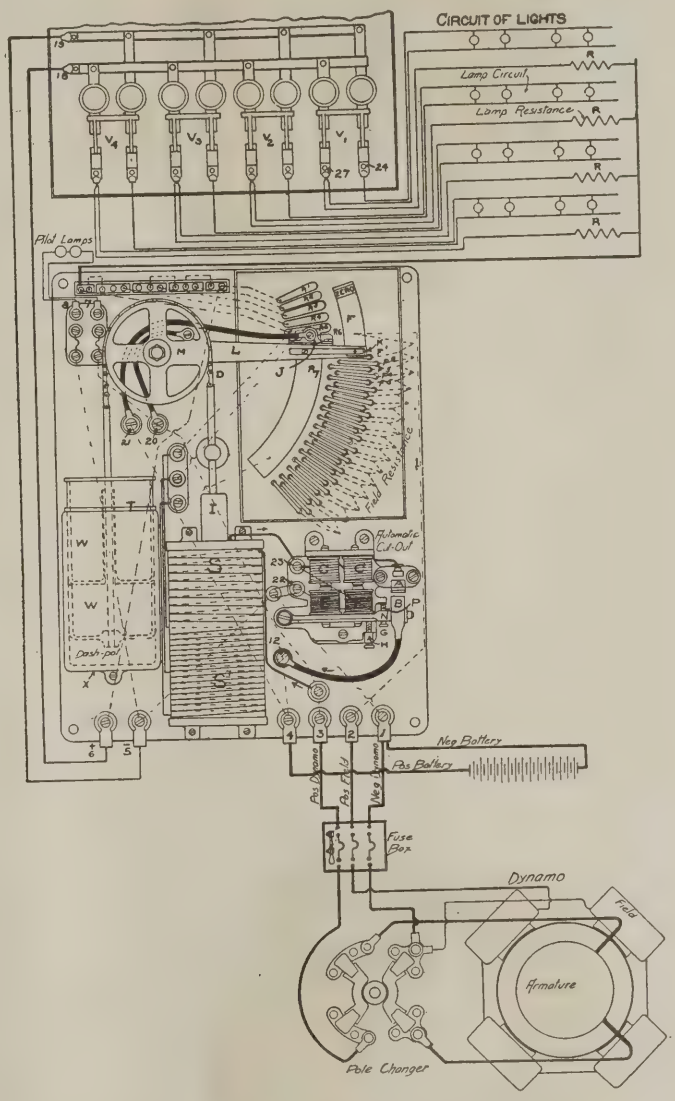


Fig. 79. Wiring Diagram Newbold System.

for in order to balance the greater weight in the dashpot (W), there will have to be a stronger magnetic pull in the coil (S) and this requires a higher generator current; while if the weight in the dashpot be lessened by removing some of the shot it will not require as high a current through the solenoid to produce a magnetic pull which will balance the weighted dashpot.

It should be noted that the dashpot plunger (W) is divided into two parts. When the equipment is not operating the upper and heavier chamber of the plunger rests on the rim of the dashpot; so that when

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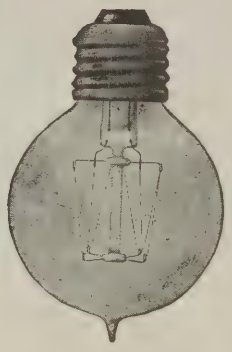

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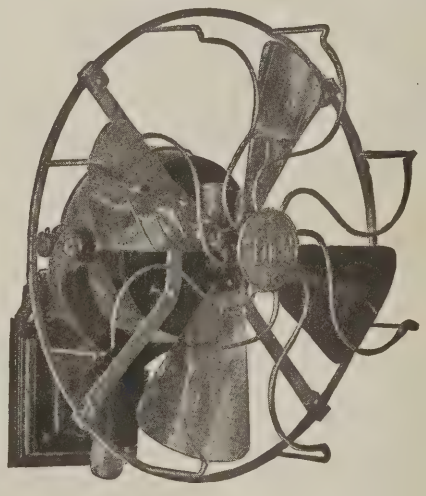

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the equipment first begins to operate and the automatic switch closes a comparatively small current through the compound solenoid (S) will be sufficient to overbalance the weight of this lower chamber. This pulls down the contact arm (L), cutting in a few segments of lamp resistance as soon as the automatic switch closes.

It should be noted that the arm (L) carries two steel contact brushes, one of which engages the segments of generator field resistance and the other, as just mentioned, makes contact with the lamp resistance segments. The condition as shown in Fig. 79 is just after the automatic switch has closed, and the few segments of lamp resistance have been cut in circuit. A further rise in generator speed will cause the plunger (I) to be drawn into the solenoid (S), cutting in the segments of generator field resistance, as explained above.

In addition to the few segments of lamp resistance which are cut in when the arm (L) first moves downward after the automatic switch closes, there are several other sections of resistance placed in the main lamp circuit. Short circuiting taps from each section, however, are run to the lamp switchboard panel, which is arranged so that as each of the circuits are cut in, an extra knife blade automatically short circuits one segment of resistance. When all the lamps are turned on this lamp resistance is entirely short circuited; but when only the night circuit is on the entire lamp resistance is in circuit.

With 50 amperes current flowing through a resistance of 1/10 of an ohm, the voltage drop through the resistance will be 50x1/10 or 5 volts. This might correspond with say two-thirds of all lamps on. With only one circuit on, however, and the current down to 10 amperes, the voltage drop through this same resistance of 1/10 of an ohm would be 10x1/10, or only 1 volt. So, in order to keep the lamp voltage constant this voltage drop through the lamp resistance must be constant at 5 volts. With the 10 ampere current this requires 5/10 of an ohm, which is just five times as much as our original resistance in producing the same 5 volt drop. This shows the necessity of the short circuiting arrangement for cutting in and out lamp resistance as employed in this equipment.

It should be noted that the main solenoid (S) is divided into two coils. One of these coils carries the total current of the generator and the other, somewhat smaller than the first, carries the lamp current only. This lamp current coil is wound differential to the main generator current coil so that when the lamps are lighted the magnetism of the lamp coil opposes that of the main generator coil, with the result that the generator current is compelled to rise somewhat higher to produce the same magnetic pull on the plunger (I) when the lamps are on than in the day time when no lamps are on and there is no opposing current flow through the lamp current coil.

By varying the number of turns in this opposing coil, the difference between day and night adjustment can be easily varied, but this is usually adjusted so as to cause about 30 per cent increase in output at night.

Results of a road test of this equipment are given in Fig. 80. The left-hand set of curves are for night operation and the right-hand set are for day operation.

It should be noted that (1) the generator output is considerably higher at night than during the day time; (2) as the train speed increases, the generator field current decreases; (3) variation in train speed causes a slight but similar variation in the generator current output—that is, a rise in generator speed causes a slight rise in generator current—this is due to the fact that at the higher train speeds the plunger (I) is drawn further down into the solenoid (S) so that the magnetism of this coil cannot act quite so effectively as when plunger is further out and accordingly a current slightly above the normal setting is required in order to produce a balancing pull on the plunger. (4) It should also be noted that the battery charging current, although small under night operation rises to nearly the full output of the generator in the day time, and that (5) the generator voltage rises from 38 volts under night operation to about 50 volts under day operation when the batteries have become fully charged.

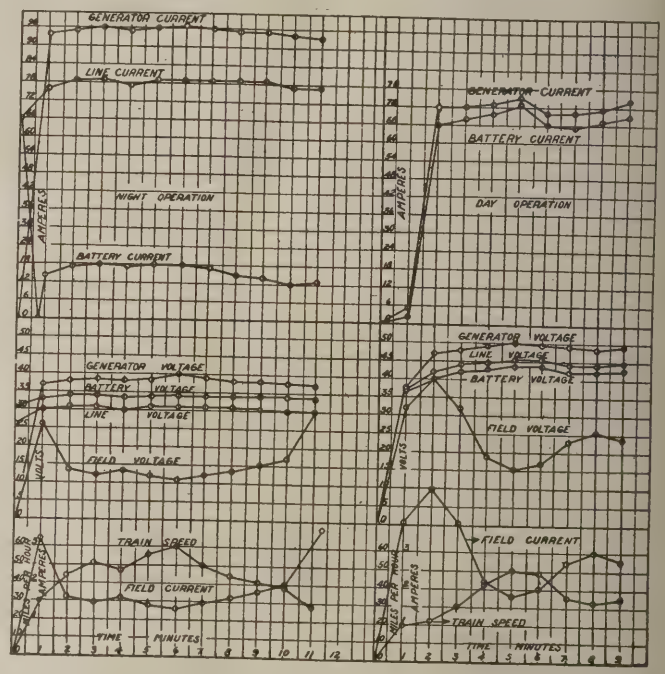

Fig. 80. Road Test of Newbold Equipment.

Generator.

The generator is of the four pole simple shunt wound type and the cast steel frame is provided with a very large hand hole for inspection and repairs. A dust-proof and water-tight bushing is fitted into the cover of this hand hole. The generator is very solidly built, there being ample provision for the heavy loads often experienced on diners, postal cars, etc. The field coils are held in place by brass retainer shoes. These are securely bolted to the frame and the ends of the bolts peined over. Oil ring bearings are supplied and these are covered by heads fastened to the frame by cap screws and provided with large oil wells and overflow pipes.

Pole Changer.

A worm or screw thread is cut on the end of the armature shaft, and this worm and gear operate all the time the generator is revolving. A friction strap clutch is mounted on a wheel connected to this gear and arranged so that when the direction of motion is reversed the friction clutch will engage the wheel and rotate the pole-changing switch through 90 degrees reversing the connection of the four pole switch.

(*Lesson to be continued next month. We have a fine bunch of Practical Stunts for next month. No room for them this time.*)

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Official Journal
of the Association of Railway Electrical Engineers.

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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Sworn to and subscribed before me this 25th day of March, 1913.

IVY L. HORDER,
Notary Public.

[SEAL.]

(My commission expires Aug. 30, 1914.)

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Ball Bearings.

In many commercial applications of ball bearings such as automobiles, etc., one of the main advantages gained by such application is their freedom from friction which means that the machines to which they are applied will be able to operate at a somewhat higher mechanical efficiency than when equipped with the plain sleeve type bearing.

Although the frictionless feature of the ball bearing may indirectly be an important element in the selection of ball bearings for axle generator service, in that the wear of the bearing is greatly reduced, the main consideration recommending ball bearings is that of maintenance. Whether the generator operates at an efficiency of 88 per cent or 92 per cent is of small consideration, but the fact that ball bearings so reduce the necessary maintenance that they may be allowed to go for six months without any inspection whatever, and the fact that they so eliminate wear and are so thoroughly reliable that a light failure due to ball bearing trouble is a most infrequent, in fact, almost unheard of thing, is of commanding importance to the railway car lighting man.

The record of service on two roads as given in another part of this issue is most gratifying indeed and during the subsequent months of this year we hope to be able to present similar service reports from various roads operating these bearings.

Axle Lighting and the Automobile.

It frequently happens that the more progressive workers in one line of engineering adopt certain features or even whole systems from another line and profit greatly thereby, sometimes developing the new application until its use is greater than in its original field.

The electric lighting system for cars is a typical example, and the present day forms for gasoline cars are essentially modifications of the axle generator systems developed for steam railroad cars years ago. They comprise generators driven by some moving element (usually the engine fly wheel), a storage battery for use when the engine is not running or when it runs too slowly, a voltage regulator and an automatic switch for cutting in and out at critical speeds.

For automobiles another feature has been necessary, that of using the generator for ignition purposes, and now comes the additional use of the generator as a motor for starting the engine. Thus is the influence of the railway electrical engineer showing itself on the newest and one of the greatest of all industries.

We congratulate the engineers of both industries that this is true, and trust that scientific automobile lighting is as near at hand as scientific car lighting.

Electrification in India.

Mr. C. H. Merz, consulting engineer for the very extensive electrification now in progress at Melbourne, has been in consultation with certain officials of India railways relative to electrification of certain congested points. The principal projects which the Indian authorities are said to have under consideration are: The electrification of the Bombay suburban lines of the Great Indian Peninsula and Bombay, Baroda and Central Indian Railways, involving from 50 miles to 100 miles of track; Calcutta suburban lines of the Eastern Bengal State Railway, beginning with 20 miles to 40 miles, and the Ghats (main line) section of the Great

Indian Peninsula Railway, involving some 30 miles. The Ghats electrification will be of special interest on account of the severe grade conditions on this important line.

Association News

Annual Convention.

At a recent meeting of the executive committee of the Association of Railway Electrical Engineers with a special committee representing the Railway Electric Supply Manufacturers' Association, it was decided to hold the annual convention of the Association in the La Salle Hotel, Chicago, October 20-24th, inclusive. Both of the large ball rooms on the top floor of the hotel will be used for exhibit purposes, while a large room on the 18th floor will be reserved for the meetings of the Association. The convention proper will not begin until Tuesday morning, the 21st, although the exhibit hall will be open for installation of exhibits Saturday at 6 p. m.

The entertainment committee have not yet formulated their plans, but without doubt the usual features as have been provided in past years will be arranged for.

Semi-Annual Convention.

It has been decided to hold the semi-annual convention of the Association at Atlantic City, June 16th. The headquarters of the Association are to be at the Hotel Dennis. We would suggest that all members of the Association, both active and associate, who expect to attend the convention arrange to make this place their headquarters.

Editor's Note:—Ordinarily we pay no attention whatever to unsigned communications received at this office. The following, however, is so nearly in accord with our own views on the subject of a complete disregard of the best engineering practice, in fact, a disregard of even common sense, that we present it herewith and take all responsibility for its publication upon ourselves.

Who Was Responsible?

The New Grand Central Terminal just recently completed and thrown open to the public stands as a fitting monument to scientific endeavor along the lines of design and construction of railroad terminals. The simple lines of the several vast interiors give an atmosphere of dignity throughout, and the impressiveness is emphasized by the many details that contribute to the convenience and comfort of the traveling public. Yet it would seem to the visiting patron, as it now surely must to those who were responsible and others of technical mind, that a most serious mistake has been made in the lighting of some of the otherwise most imposing sections. At every turn one is greeted by a large exposed lamp or cluster of lamps glaring directly into the eyes. No shade or other method of concealing the light source has been provided, and the use of a powerful incandescent lamp in its present high state of perfection means discomfort and punishment not unlike a slap in the face to every person who glances in its direction.

That the more pleasing effect in the suburban concourse, due to the protection offered by the beams in the ceiling, is purely accidental, is evident from the brilliant lamps left exposed at either end. Here is the only instance where the eye has been protected from abuse.

How does it happen that such a situation, seeming almost criminal "in the eyes of many," exists in such an attractive edifice? Who was responsible?

Certainly not the master minds who conceived this magnificent monument to modern civilization. Undoubtedly some one in whom responsibilty was misplaced by his inability to meet in a modern and rational way this most important matter of lighting.

A great movement toward this end was started several years ago—in fact, the moment the tungsten filament lamp with its great brilliancy was placed on the market—at first unconsciously, perhaps, but grew in force and scope in all sections of the country, until now numerous attractive devices and methods are used, all with the object of protecting the eye from the injurious exposure to these intensely bright light sources.

That a grievous error has been made in the lighting of this otherwise perfect building is self-evident to the most casual observer. To the technical engineer must come a feeling of regret that in this important matter modern methods have not been employed.

The millions who pass through the portals of that terminal will, without exception, marvel at its spaciousness and convenience. In their endeavor to grasp the beauties of architectural lines and decorations, they will meet with a "slap in the face," as it were, by the thousands of lights from whose brilliant glare it will be impossible to obtain relief by turning in any direction.

RAILWAY CAR LIGHTING IN INDIA.

In an article on this subject "Indian Engineering" states that several systems of electric lighting in trains are in use, but Stone's system has been adopted as the future standard for the three State railways (North-Western, Oudh & Rohilkhand and Eastern Bengal), most of the carriages on which lines are at present lit by gas.

On Dec. 31, 1911, there were 12,831 cars on the several Indian railways fitted for (Pintsch's) gas lighting (compared with 12,455 a year previous), and 4,584 (3,636 year previous) for electric lighting. The number of cars on the various railways fitted for electric lighting were as follows: Bengal Nagpur, 62 (the systems represented being Stone, Mather & Platt, Vickers-Hall, Bowman & Still); Bombay, Baroda & Central India, 83 (Stone, Vickers-Hall, Aichele and Vicarini-Crawford); Eastern Bengal, 20 (Stone, Vickers-Hall, Mather & Platt and Tudor); East Indian, 120(Stone); Great Indian Peninsula, 216 (Stone, Aichele, Vickers-Hall, Vicarino-Crawford, Mather & Platt and Tudor); Madras & Southern Mahratta, 14 (Stone, Vickers-Hall, Tudor and Rosenberg); Nizam's Guaranteed, 138 (Stone); Oudh & Rohilkhand, 78 (Stone and Vickers-Hall); South Indian, 40 (Stone); Assam-Bengal, 1 (Vickers-Hall); Bengal & North-Western, 1,088 (Stone); Bengal-Dooars, 45 (Vickers-Hall); Bharnagar, 16 (Vicarino-Crawford); Burma, 65 (Stone, Vickers-Hall and Vicarino-Crawford); Dibru-Sadiya Colliery Railway, 1 (Vicarino-Hall); Eastern Bengal, 17 (Stone and Vickers-Hall); Gandal-Porbandar, 24 (Vicarino-Crawford); Hyderabad-Godaveri Valley, 3 (Stone and Vicarino-Crawford); Jodhpur-Bikaner Native State, 258 (Stone); Junagadh, 4 (Vicarino-Crawford); Madras & Southern Mahratta, 4 (Stone); Rajputana-Malwa, 1,322 (Independent Storage Battery); Rohilkhand & Kumavon, 158 (Stone); South Indian, 485 (Stone) and the following light 2 ft. 6 in. gauge railways: Arrah-Sasseram, 28 (Mather & Platt); Baraset-Basirhat, 45 (Mather & Platt); Barsi, 49 (Stone and Leitner-Lucas); Dholpur-Bari, 7 (Independent Storage Battery); Kalka-Simla Mountain, 113 (Stone); North-Western light military lines Kohat-Thal and Nowshera-Dargai, 9 (Stone); Shahdara (Delhi)-Saharunpore, 35

(Mather & Platt); Darjeeling Himalayan 2 ft. line, 30 (oil motor driven direct-connected 60-volt generating set in baggage car). The total percentage of vehicles fitted with gas and electricity is 80.14 per cent, while 4,317 vehicles, or 19.86 per cent, are not fitted.

Pennsylvania Electric Tractor for Use on City Streets

In order to replace the string teams used for hauling cars over railroad tracks in city streets for delivery to patrons, the Pennsylvania Railroad has recently designed and constructed an electric tractor in its Juniata shops. Several commercial motor trucks and tractors were tried out and found wanting before the design of this tractor was originally undertaken. As

Side View of Electric Tractor.

is the practice in baggage-handling trucks, this tractor has been designed to drive, steer and brake on all four wheels. This feature becomes necessary because of the fact that the tractor very often operates in close quarters; driving from all four wheels, moreover, gives a considerably greater possible tractive effort than from two. The tractor can turn in a circle of 20 ft. radius, and the trailing wheels track with the forward wheels so that any obstruction which the forward wheels clear will be cleared by the rear wheels also. This allows the operator to devote his entire attention to the forward end of the tractor.

The principal dimensions and operating characteristics of the tractor are as follows:

Length over couplers	23 ft.
Length over chassis	19½ ft.
Wheel base	12½ ft.
Diameter of wheels over tires	5 ft.
Tread of wheels	7 ft
Width of tires	12 in.
Width over all	8 ft. 4 in.
Height over all	11 ft. 3 in.
Size of cab	7 ft. x 7 ft. 6 in. x 7 ft. high
Weight	28,850 lbs.
Drawbar pull (normal)	8,000 lbs.
Speed (normal light)	6 miles per hr.
Battery	80 cells of Edison A-12H
Weight of battery	4,350 lbs.

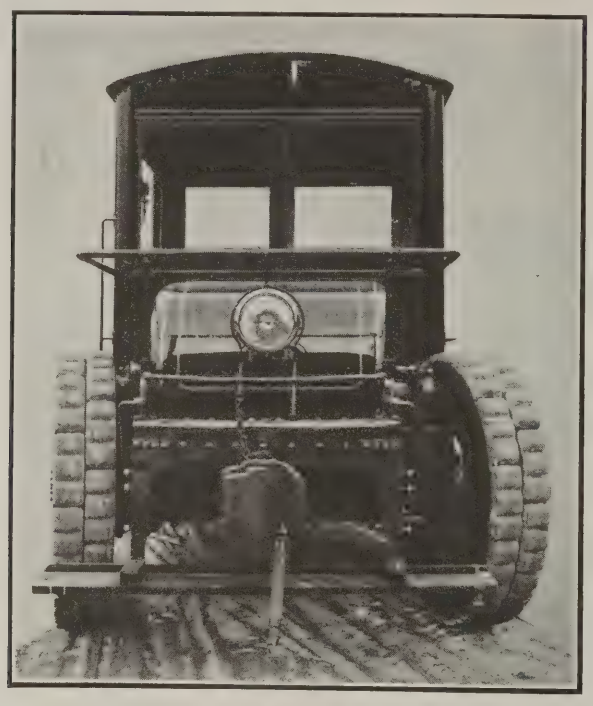
The wheels and driving mechanisms are located near each end of the chassis, and the battery box containing 80 Edison A-12-H cells is hung in the center directly under the cab. Two 20-h.p. G. E. motors are mounted with the balance of the driving mechanism on each axle. These axles are the largest automobile axles ever built. Each motor is geared through a set of herring-bone gears to a counter shaft, a special flexible coupling being required between the armature shaft and the herring-bone pinion. Integral with the counter shaft gear is a differential gear of special design which is the largest differential gear ever built for automobile work, and is a new departure in differential construction. Each side of the differential drives a section of the split counter shaft. Each section of the countershaft carries a universal pinion which meshes with the driving gear that is bolted to the wheel casting.

The wheels consist of steel castings of the tangent spoke type, weighing approximately 1,200 lbs. each. Solid rubber block tires are provided, which are of such design that any one block may be removed and replaced without disturbing any other section. Each of the four wheels is carried on a steering knuckle which connects through a system of levers to the longitudinal steering shaft on the main bed of the tractor. This longitudinal steering shaft is divided into two sections, coupled together at the center by an interrupted crank. This coupling is connected through a system of gearing to a large steering wheel in the center of the cab. This steering wheel is of the marine type and turns the tractor in the direction the top of the wheel is turned regardless of which end of the tractor is forward. There are two controller boxes, one on each side of the steering wheel, so that the operator can drive from either side of the wheel. The connections of the starting box are such that the handle is moved in the direction that the tractor is to go, a guard preventing the operator from cutting into reverse before first coming to a full stop.

A motorman's brake valve is mounted on each side of the cab within easy reach of the operator, and this controls the operation of the air brake apparatus. This is of the automatic type, air being supplied to the main reservoir by a motor-driven compressor. The brakes carried on the tractor wheels are of the internal expanding type. Standard air brake hose couplings permit of the air braking apparatus of the tractor operating the air brakes of the cars which are being

shifted. In addition to the air brake apparatus, a hand brake is supplied which may be used at any time.

From the data given above it will be observed that the normal drawbar pull of the tractor is 8,000 lbs. This is based on a co-efficient of friction of about one-fourth. During a recent trial at the Juniata shops it easily pulled a locomotive and two cars. Subsequently



End View of Electric Tractor.

the locomotive and tractor were pitted against each other to see which was the more powerful. With the locomotive throttle wide open it failed to hold the tractor; in fact, was moved backward several feet. The locomotive used was a class R and is rated at 21,500 lbs. drawbar pull.

WESTERN ELECTRIC SALES CONFERENCE.

During the week of February 24-28 the Western Electric salesmen from the middle western states held a big sales conference at the Chicago office of the company. This conference is unique in that it is virtually a special training course in the technical features of the many products handled by the Western Electric Company.

A large number of manufacturers as given in the following list exhibited their apparatus on the seventh floor of the Clinton Street Building.

Frank Adams Elec. Co.
American Cross Arm Co.
American Elec. Heater Co.
American Ever Ready Co.
American Washer Co.
Benjamin Electric Mfg. Co.
The Bryant Elec. Co.
George Cutter Co.
Crouse Hinds Co.
Duncan Elec. Mfg. Co.
D. & W. Fuse Co.
Thomas A. Edison, Inc.
Edwards & Company.
Electric Storage Battery Co.
General Electric Co.
General Electric Ry. Material Co.
Habirshaw Wire Co.
The Holophane Wks.
Hubbard & Co.
Harvey Hubbell, Inc.
Hughes Elec. Htg. Co.
Mathais Klein & Sons.
W. H. Matthews & Bro.
Natl. Metal Molding Co.
Pittsfield Spark Coil Co.
Stanley & Patterson.
B. F. Sturtevant Co.
Sunbeam Lamp Co.
R. Thomas & Sons Co.
The Tungstolier Co.
Western Elec. Co.
Interphone Dept.
Switchboards.
Telephones
Misc. Material.
Westinghouse Elec & Mfg. Co.
Weston Elec. Inst. Co.

One or more manufacturer's representatives was on hand at all times to explain in detail the technical engineering features of each particular type of equipment.

The 105 Western Electric salesmen attending the conference were divided into groups of three men each, with instructions to visit every exhibit some time during the conference week. Each man was supplied with a set of cards, one card for each exhibit. After the visit of each group of salesmen to any particular booth, lasting from 15 minutes to one hour's time in some cases, during which the various technical points of equipment were brought out, the manufacturer's representative would retain the card for each man and indicate thereon the proficiency of each salesman in regard to that particular equipment.

These cards will then be retained by the Western Electric management and will form a most valuable basis for further instructing their salesmen in the lines in which they happen to be weakest. Without a doubt this is a most excellent idea for increasing the efficiency of a sales organization handling a diversity of lines, and one which as it is continued for succeeding years will become more and more valuable, for before next year's conference that salesman who is weak in any particular this year will thoroughly post himself.

On Friday the salesmen attending the conference visited the Hawthorne factory of the company and in the evening an informal banquet of over 500 men from the sales and engineering departments of the company was held at the Chicago Athletic Club.

BATTERY LOCOMOTIVE FOR CAR SHOPS.

The Milwaukee Electric Railway Company recently installed a storage battery locomotive at its Cold Springs shops for shunting railway cars and for moving cars over unelectrified tracks in shop buildings and on the turn table. The locomotive weighs seven tons and can attain a speed of about five miles an hour when handling a 22-ton car. It is equipped with both the standard M. C. B. coupling for railway cars and a coupling for handling its own rolling stock. The storage battery consists of 44 "Iron-clad" Exide cells which operate two double-geared, traction type, 80-volt motors. The locomotive may be operated from a controller at either end. With a normal charge, the locomotive is able to operate between two or three weeks without recharging under its present schedule.

THE WESTERN MARYLAND INSTALLS TELEPHONES FOR DISPATCHING TRAINS.

The Western Maryland Railroad Company has joined the ranks of the railroads using the telephone for the dispatching of trains and has recently ordered equipment for its lines from the Western Electric Company. This road, which is an exceedingly busy one, especially since the opening of the Pittsburgh extension, is used principally in the hauling of coal, coke and other freight and also handles passenger traffic.

The apparatus to be used is the No. 102 type selector set containing the well-known No. 50 selector. Twenty-three way-stations will be equipped with selective signaling and telephone apparatus. Miscellaneous equipment and line material is also being furnished.

The present equipment will be installed over a circuit extending from Hagerstown, Maryland to Cumberland, Maryland, a distance of eighty miles. This section of road is the first of four hundred miles to be equipped with telephone train dispatching apparatus.

Car Lighting Specifications

F. E. HUTCHISON, Chief Electrician Rock Island Lines

The intention of this specification is to provide for all labor, tools and materials required for the furnishing of electric lighted cars complete with all electric appliances in a neat and workmanlike shape.

The car builder will get out blue prints of the details and application as he interprets lighting arrangement and submit them to the Railroad Company for approval before starting work.

Builders must in all cases assure themselves that the specifications in their possession are of the latest revision.

Equipment.

To consist of a 40 volt —— kilowatt dynamo, suspension and driving apparatus, switchboard, regulating devices for dynamo and lamp voltage control, fixtures and all wiring, a 32 volt storage battery, 280 ampere hour capacity. Railroad standards on above to be furnished.

Dynamo Suspension.

Will be so constructed that it will locate the dynamo so that the belt will clear the top of the end sill 1" from the top of the end sill to the underside of the belt and so that the belt will clear the brake beam and other obstructions at least 2" when the brake shoes are worn out, also so that the dynamo and parts of the suspension will clear anything on the bottom of the car (brake rigging, etc.) at least 4". It must be firmly braced and secured to truck frame.

Battery Box.

To be made of ⅛" steel, well constructed and painted, tight to keep out dust and snow, located underneath car and substantially secured to body of car. It is to be divided into two compartments each having inside dimensions of 22" high, 28" deep and 45" long. Each compartment to be ventilated by four 2" holes in bottom of box, covered by wire netting, the holes to be bushed with lead pipe flanged over ½" inside of box. A cast iron ventilated battery box door handle on each door. Interior of box to be lined with wood ¾" thick on top, sides, ends and doors, 1" thick on bottom. Wood to be saturated with paraffine and beeswax. The wood lining to be put in so that it can be easily renewed. Conduit entering box shall be ¾" and run from junction box to fuse box, one fuse box to be located on each end of battery box and secured to same. The doors of battery box to be arranged so that the right hand door can be opened without opening the left hand door.

Westinghouse Hand Connectors.

Male part to be soldered to the positive battery wire. (right) The female part to be soldered to the negative wire (left where they terminate in battery box. This connector will be furnished with the battery.

Shipment of Batteries.

The batteries shall not be delivered to the car builder's factory more than thirty (30) days previous to the delivery of the car to the Railroad Company and they are to be kept charged and flushed by the Car Builder to prevent sulphating, etc.

Regulator and Switchboard Locker.

To be made in two compartments; regulating devices installed in lower part and switchboard in top part. Lower door to have a knob and lock. The upper door to have an approved latch. A shelf will be placed between the two compartments.

Locker will be at least 12" deep and 24" wide and 6' 11" high. It will be well ventilated and top locker will be provided with racks to carry extra lamps. It will also be provided with a box for fuses. It will have two locker lights, one in each compartment.

There will be a 63 volt green Pilot Lamp mounted directly above the top door of the regulator locker so that it can be readily seen by train crews. The finish of the receptacle shell to be the same as other fittings in car. The wires for this receptacle shall be connected to the negative generator and positive field terminal of the apparatus or pilot light terminals on apparatus so that it will not burn when the main positive generator fuse or field fuse has blown.

The locker light receptacles to be mounted on condulet No. ——½" conduit to be run from "H" condulet through "Z" iron behind switchboard and regulator.

The regulators and switchboard will be mounted on 2" "Z" bars made of ⅛" sheet steel, all wiring to be run behind these "Z" bars. Open spaces between boards to be neatly paneled with steel and bushed for wires going through.

Car builder will place a tin receptacle in each switch locker for report forms and will frame any prints or instruction cards required by the Railroad Company.

Switchboard.

The switchboard to be a dull finished slate on which is mounted *approved* double pole single throw fusible knife *circuit* switches fused with 10 ampere Edison plug fuses, and is to have three (3) 75 ampere double pole single throw fusible knife switches. Left hand switch to be marked "Battery"—center switch to be marked "Lights"—and right hand switch to be marked "Train Line."

It is to be furnished by the Car builder when it is not furnished by the manufacturer of the axle lighting equipment, the design to be approved by the Railroad Company. Positive to be maintained to the right in all connections and is to be wired as per the Railroad Company's drawing.

Train Line Connector.

One per car to be 42" overall, made up of two 3-G two finger male plugs and two flexible No. B&S gauge stranded cables. Cables to be soldered into brass sleeves which are to be spoted with a drill to take connector screws.

A place for storing this connector will be provided, supporting hook per Railroad Company's drawing a strap of 1/16" iron will be arranged to hold bottom of connector.

Connector Supporting Hook.

An approved hook shall be placed 12" to the right, when facing car from center line of receptacle, for supporting the connector wires of male connector when in use.

Train Line Receptacles.

Two per car, 3-G two finger type female receptacles, one on each end of car located 6" to the left of center line of car to center of receptacle when facing car; positive to be right, negative to be left when facing car. Shed type No. ———or angle type No. ——— will be used according to design of car.

Charging Receptacle.

There are to be two ———— new type —— double pole, 65 ampere swivel charging receptacles with casting extended to take strain off contacts, mounted underneath the car attached to the body of same, one on each side of the car, located as near the center of the car as possible, and back 4" from side of car to cover on receptacle, outside ring to be connected positive and center post to be connected negative.

Steam Drops.

Will be equipped with strong galvanized iron shields to prevent the condensation from striking dynamo.

Wiring.

All insulated wires and cables used in wiring these cars shall be double braided ———— wires or cables, No. 6 B&S or larger sizes to be stranded.

Circuit wires shall not be smaller than No. 12 B&S gauge wire. Not more than 300 watts will be connected to any one circuit. The wiring will all be done in *approved* conduit with substantial water-proof junction boxes. No conduit to be on top of car roof. There is to be no wire pulled into conduits until all wire ducts are in place, thus assuring that the wire can be pulled out and repaired without disturbing the finish of car.

Train Line Wires.

Cars to have a two wire train line. Wires to be No. 2 B&S connecting to female train line receptacles at each end of car. They are to be run in conduit to within 12" of receptacles. They are to be connected to train line switch with two No. 4 B&S wires. The conduit will be arranged so wires can be pulled out for repairs or inspection and put back easily.

Wiring and Conduit Arrangement Underneath the Car.

Positive and negative battery wires to be No. 4 B&S and to run from their respective terminals in the battery box through 100 ampere N. E. C. fuses, knife blade type, to regulator locker.

Positive and negative dynamo wires to be No. 4 B&S and to run direct from generator terminal block to switchboard locker, there being no common negative connections to be made outside of regulator locker.

Positive generator field to be No. 8 stranded wire, run from generator terminal block direct to regulator locker.

The connections to the controlling apparatus to be made to the correct terminals for the various wires as provided on the regulating apparatus by its manufacturer.

All wires leading from the main regulator to generator, battery box, automobile charging receptacles, to be run in conduit with a condulet fitting, with 3 wire porcelain cover on the end of the conduit from which the wires lead to dynamo terminal block. The ends of all conduits must be carefully reamed and bushed.

The distribution underneath the car shall be from four junction boxes and two fuse boxes*, one main junction box which is to be 4" deep, 8" wide and 10" long. The three boxes—one of each is to be used at each terminal of the battery box and the other one to be used for distribution to the two type "C" charging receptacles. They are to be 4" deep, 6" wide and 8" long. These boxes are to be substantially built and water-proof. The covers are to be secured with 5/16" cap screws. All the bosses on the box providing places for drilling for the cap screws which hold the cover and for the drilling and tapping of the pipe, are to be made on the outside of the box so that the inside will have a clean smooth surface.

All conduit in car shall be of sufficient size to permit of the pulling in and out of the wires for repairs or inspection without crowding. It shall be run with as few bends as possible, and securely fastened to the body of the car.

All splices to be soldered and taped with rubber tape equal to the thickness of the insulation of the wire and again taped with friction tape equal to the strength of the braid of the wire.

*Fuse box to be as per M. C. B. Exhibit "F."

60' BAGGAGE CARS.

Conduit in Car.

To be run exposed on the interior of car with condulets provided for light openings and branch to switchboard locker for circuit wires and train line taps.

Location of Switchboard Locker.

It is to be located so as not to take up valuable storage room.

Pilot Light Receptacle.

It is to be mounted on a No. H 15 condulet.

Switchboard and Regulator Locker.

It is to be steel as per Railroad Company's tracing.

Location of Battery Box.

It is to be applied on opposite side of car from that occupied by express safe.

Dummy Wood Male Plugs.

Two per car, are to be made of maple painted black, (with exception of fingers) fashioned after the standard

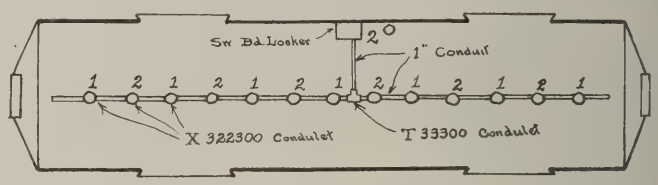


Fig. 1. Layout of Baggage Car.

3-G male plug and fastened to each end of car by a chain 10 inches long.

Circuits.

Location	Circuit Number
Center	No. 1
Center and over desk	No. 2

Lighting Fixtures.

Number Required	Catalogue Number
1	Bracket
13	Shade Holders
14	Shades

Lamps.

Number Required	Watts	Volts	Style	Color	Type of Filament
16	15	34	G 18½	Clear	Tungsten
1	25	63	SS 17	Green	Carbon

DINING CARS.

Location of Dynamo.

Dynamo is to be applied to truck opposite end of car from kitchen.

Conduit in Kitchen.

To be run exposed with condulets used for junctions, light and switch openings. Condulets J-J-K type with porcelain receptacles to be used for light openings. FD and FDC type for switch openings. Condulet will be neatly bent and securely braced and fastened.

Conduit in Ice Boxes.

To be run down corner of boxes exposed entering at top of box. It will run through top and bottom compartment condulets to iron door switch box. Conduit is to be connected solid all the way through ice boxes.

Installation of Exhaust Fans.

Exhaust fans to be installed so they can be easily taken down for cleaning and repairs.

To Have Separate Switch Control.

Kitchen fans by push switch on condulet.

Kitchen lights by push switch on condulet.

Each circulating fan in dining room by Pullman rotary flush switch.

Each exhaust fan in dining room by Pullman rotary flush switch.

Pantry lights by Pullman rotary flush switch.

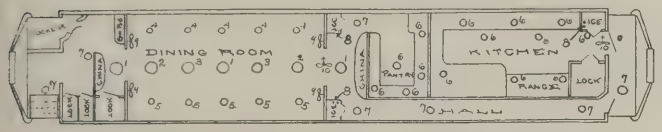


Fig. 2. Layout of Diner.

Each ice box by door switch mounted in iron box to which conduit is connected tight and solid.

Lighting Fixtures.

Location	Number Required	Catalogue No. of Fixtures	Catalogue No. of Shades
Center deck	7		
Side deck	10		
Hall and vestibule	6		
Passageway, Conductors end	1		
Pantry center	1		
Pantry, under shelves	4		
Kitchen	9	J & K type Condulets)	Furnished by
Ice boxes	6	J type Condulets)	Car Builder
38 15	34	G 18½ Clear	Tungsten
1 25	63	SS 17 Green	Carbon

Fans.

Location	Number Reqeuired	Volts	Type
Dining room	4	32	12" Circulating
Dining room	1	32	Exhaust Blower Ventilator
Kitchen	1	32	Exhaust Blower Ventilator

Lamps.

Number Required	Watts	Volts	Style	Color	Type of Filament
8	50	34	G 30	Clear	Tungsten

Circuits.

Location	Circuit Number
Center dining room	No. 1
Center dining room	No. 2
Center dining room	No. 3
Side dining room	No. 4
Side dining room	No. 5
Kitchen and pantry	No. 6
Hall and Vestibule	No. 7
Ice boxes	No. 8
12" circulating fans	No. 9
Exhaust fans	No. 10

70' CHAIR CAR OR COACH.

Lighting Fixtures.

Location	Number Required
Center	12
Toilets	2
Vestibules	4

Lamps.

Number Required	Watts	Volts	Style	Color	Type of Filament
12	50	34	G 30	Clear	Tungsten
8	15	34	G 18½	Clear	Tungsten
1	25	63	SS 17	Green	Carbon

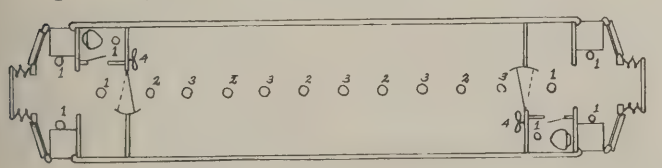


Fig. 3. Layout of Coach.

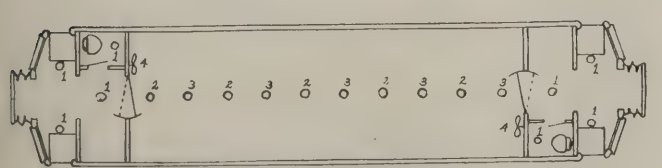


Fig. 4. Layout of Chair Car.

Fans.

2-12" 32 volt fans with switch in base

Circuits.

Location	Circuit Number
Toilet, hall and vestibule	No. 1
Center	No. 2
Center	No. 3
Fans	No. 4

60' 3 COMPARTMENT CAR.

This plan for location of lights and circuits only.

Lighting Fixtures.

Location	Number Required
Center	11
Toilets	3
Vestibule	4

Lamps.

Number Required	Watts	Volts	Style	Color	Type of Filament
11	50	32	G 30	Clear	Tungsten
9	15	32	G 18½	Clear	Tungsten
1	25	63	SS 17	Green	Carbon

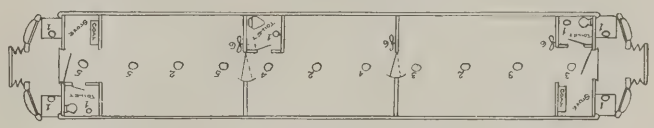


Fig. 6. Layout of Jim Crow Compartment Car.

Fans.

3-12" 32 volt fans with switch in base.

Circuits.

Location	Circuit Number
Toilets and vestibule	No. 1
Center	No. 2
Center	No. 3
Center	No. 4
Center	No. 5
Fans	No. 6

THE OVERLAND LIMITED.

A new extra fare train has just been put in service on the C. & N. W., Union Pacific and Southern Pacific Railroad, operating daily between Chicago and San Francisco. The train makes the run in 64 hours, being three nights and two days on the road.

The train affords the traveling public all modern comforts and luxuries known in railway travel today. In addition to electric lighting, electric fans, telephone and telegraph service usually provided, there is a shower bath equipment installed in the barber shop. Stenographic services and market reports are also available, so that the busy business man may accomplish a considerable amount of work en route.

Although apparently no expense has been spared in making this train one of the finest in the country, it would seem that the matter of eliminating glare and eye strain of the passengers has been sorely neglected. The unshaded, bare tungsten lamp is very much in evidence, both on side wall reading lamp fixtures and on the four corners of gas combination fixtures. Even where diffusing globes and shades have been provided, these are simply of ground glass which, aside from its decorative effect, is but little better than the bare lamp. The low efficiency of such installations may not be of great importance because of the fact that power is supplied from the headend turbo generator set, but the fact that bare lamps in the field of vision greatly reduce one's ability to see and, particularly on long runs where such a row of bare lamps are in the passenger's eyes for hours, the effect is most annoying, in fact, injurious to the eye. With all the information now published on this subject, and with scientifically designed fixtures available which provide efficient and proper distribution of the light at the same time and eliminate the effect of glare, it is unfortunate that roads will persist in old style methods and equipment.

Ball Bearings in Car Lighting Service

F. H. POOR

EDITOR'S NOTE.

This is the third of a series of educational talks on the subject of bearings written by certain authorities on this subject who are connected with some of the various bearing manufacturers.

It is a well-known fact that the efficiency, or ratio between the input and output of work, shows if a machine is working satisfactorily or not. The higher the efficiency is the more productive the machine becomes. It is also well known that the greatest amount of actual lost work is chargeable to friction, and the elimination of this friction is a problem of prime importance for any type of machine.

There are two kinds of friction to contend with, sliding friction and rolling friction, and in making comparisons between the various types of bearings in which these two types of friction are found, we have sliding bearings, roller bearings and ball bearings.

In comparative tests of these various types of bearings the sliding bearings show a co-efficient of friction which varies considerably for changes in speed, from .03 at low speed to .125 at higher speed.

Roller bearings show a somewhat closer range in the co-efficient of friction, but both the roller bearing and the sliding bearing are far in excess of the friction of the ball bearing, and both show a very much higher co-efficient of friction at low speeds.

The great superiority of the ball bearing is found in the fact that the co-efficient of friction varies between very close limits at different speeds and loads, and that the starting friction is practically no greater than is to be found under normal running conditions.

Friction in sliding bearings is dependent on the bearing surfaces, the lubricant, the method of lubrication, the load to be carried and the pressure per unit of measurement, as well as speed and temperature.

It is a difficult problem to properly select the right composition for bearing bushings under different conditions of speed and load. The shaft must be turned and ground extremely close. The bearing bushings must be scraped down to fit the shaft perfectly, and in placing the bearings in service great care must be taken in the selection of the lubricant, and in watching the operation of the bearing, because of the tendency of sliding surfaces to develop such an amount of friction that the temperature rises to a dangerous point on first placing the bearings in service.

Most bearing linings are made of compositions that are poured into a cast-iron bushing, and these compositions must be uniform if good results are to be obtained. If the composition is overheated, or allowed to harden too slowly, the bearing surfaces are almost certain to lack uniformity, and there have been many cases where bearing metals consisting of lead and antimony poured in the usual way have shown antimony crystals in the upper half of the bearing, while the main body in the lower half of the bearing was entirely free from antimony. This result shows clearly that the hardening of the composition had been too slow, and antimony had had a chance to float to the top. The bearings in this case were too hard where the antimony collected, and rapidly ruined the shaft, while the lower halves were too soft and were cut.

In speaking of wearing out and heating of bearings, the writer may mention the case of a large planing mill in Sweden which was equipped throughout, with the exception of one bearing, with S. K. F. Ball Bearings. This one bearing was in such a position on the floor that it was surrounded by chips, shavings and dust from the planing mill. After having been run under heavy duty one day this bearing became hot, ignited the shavings, and the whole planing mill was burned to the ground. If this mill had had one more S. K. F. Ball Bearing instead of this single plain bearing, it is probable that the fire would not have taken place.

Fig. 1. Section Through S. K. F. Ball Bearing.

In connection with the question of lubrication for bearings, it may be said that the object of lubrication is to decrease friction and the heating of sliding surfaces in such manner that the friction between the shaft and the bearing is transferred into friction between the shaft, lubricant and bearing, or, as it is called, "liquid friction," where, due to easy movement of the oil particles among themselves, the friction is considerably less than between the shaft and bearing. To attain this result the oil must have enough body so that it is not squeezed out from between the bearing surfaces. The less heavy flowing the oil is, however, the less is its own friction, and at the same time the lower the co-efficient.

To obtain the least amount of friction in a plain journal, we must determine what viscosity is best at a certain temperature, medium load and velocity, and after that select the best oil. These determinations are in many cases extremely difficult.

Ball bearings, on account of their superiority over other types of bearings, are rapidly superseding them for the following reasons:

1. There is less loss of power owing to the lower co-efficient of friction. This statement is based on results from actual tests, where savings in friction have been shown to be from 80 to 85 per cent.
2. The friction in a ball bearing has practically nothing to do with the viscosity of the lubricant or the temperature.
3. The resistance of friction at starting is lower than any other type of bearing.
4. The scraping and fitting of shafts within plain bearing housings is entirely eliminated.
5. There is no danger of the bearings running hot.

6. Machines employing ball bearings can be made very much shorter, owing to the fact that the bearing housings are materially reduced.

7. A properly designed ball bearing possesses the inherent ability to adjust itself to deflections of a shaft, or a spring in the framework, due to differing load conditions.

It is to be understood, however, that the above statements hold true only in such bearings as have:

1. The right kind of material.
2. Good machine work.
3. Proper construction.

In determining the carrying capacity of a ball bearing, experiments have shown that the sustaining capacity is dependent on the size of the balls and the speed at which the balls rotate.

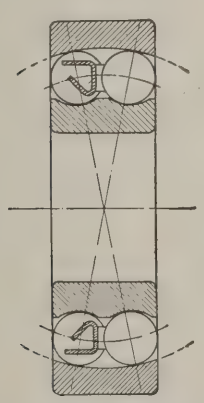


Fig. 3. Section Diagram Through Bearing.

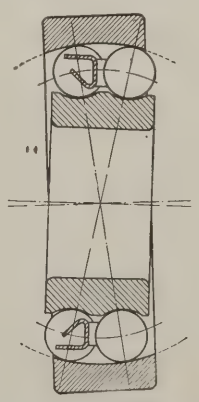


Fig. 4. Same with Shaft Slightly Deflected.

The reason why a large ball can take less load than an increased number of smaller balls is because with an increased volume to the ball it is more difficult to obtain thorough and uniform hardness. This renders its carrying capacity less in proportion to its diameter.

Insofar as the question of speed is concerned, it may be said that the fatigue of steel in a bearing is caused by the number of load applications, and not by the rapidity with which the balls and races are subjected to these loads.

It is, of course, absolutely essential that all the balls should be finished spherically, and for one and the same bearing they must be as nearly the same size as possible. A large ball in a bearing will accept more load and become overloaded, and because of the fact that it has a higher velocity in the races than the smaller balls will cause sliding friction either between the balls and retainer or between the balls themselves.

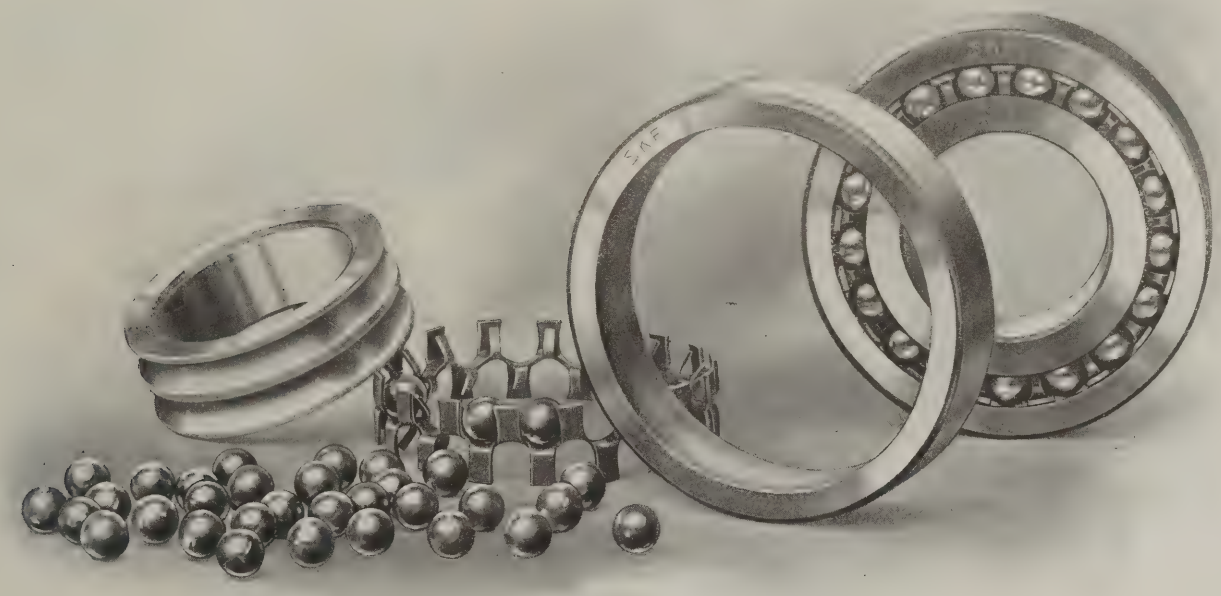


Fig. 2. Various Parts of S. K. F. Bearing.

First-class balls are now manufactured within the limits of sphericity of .00008 and are assorted in classes in which the diameter of the balls does not vary more than .00008 for use in the bearings.

A ball bearing of the right design must comply with the two following requirements: The balls must have pure rolling motion, and the races must be so designed that they give a maximum bearing surface.

To fulfill the first requirement, the tangents to the balls at their points of contact must be parallel to the axis of rotation of the balls, and insofar as the design of the races is concerned the design employed in S. K. F. Ball Bearings has in many cases proved that the races have in this construction the largest sustaining capacity for the balls, and provide a very much better distribution of load within the bearing.

These give increased reliability because the bearings, without increasing their normal dimensions, have a double row of balls, and the ball contacts on both races are equal. A larger contact on one race than on the other, as is to be found in some types of

ball bearings, does not increase the carrying capacity of the bearings, but increases the friction.

The S. K. F. Ball Bearing Company has designed its radial bearings in such a manner that both contact surfaces on the inner and outer race are equivalent in size and have the added advantages that it is a self-aligning bearing. The outside race is spherically ground, and the bearing automatically adjusts itself to any deflection of the shaft. This feature is distinctly shown in the two cuts, Figs. 3 and 4.

In discussing further the necessary features of ball bearing construction, it should be emphasized that the best material must be selected, material which has the greatest possible hardness in conjunction with toughness after hardening. The steel must be free from slag, perfectly homogeneous, and hardened uniformly throughout. The best steel available should be forged, or rolled, so that the grain is as close as possible.

Added to these requirements for a good steel, it is hardly necessary to point out that ball bearings for

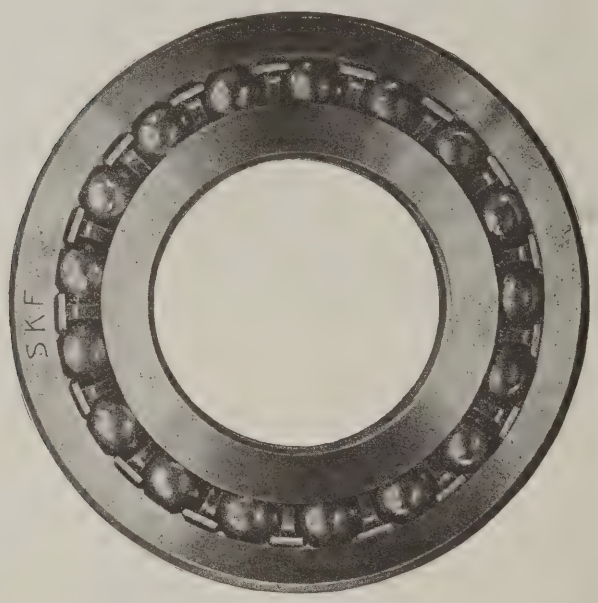


Fig. 5. Side View of S. K. F. Radial Bearing.

durable service require a very high grade of machine work under skilled labor, effective inspection and careful assembly.

In considering the selection of ball bearings for various classes of machine work there are a few general rules which must be borne in mind at all times, if the ball bearing is to operate to its fullest advantage. These rules, briefly stated, are as follows:

1. The load to be accepted by the ball bearing must be determined as closely as possible before the selection of size is undertaken, and the condition of this load, whether steady or variable, or subject to shocks, are factors which will determine whether or not a light type, medium type, heavy type or extra heavy type bearing is required.

2. In mounting care must be taken that the bearing cannot be squeezed out of round.

3. On a revolving shaft the inside race of the bearing should be fastened securely to the shaft either by means of a nut or some other locking device, which makes the inner race practically an integral part of the shaft.

4. The outer race should have a "sucking" fit in the housing. A sucking fit will allow the outer race to rotate slowly when the bearings are in operation, and thereby distribute the load over the whole inner surface of the race, without having it bear continuously in one section.

5. Only one bearing should be held sideways to take lateral movement of the shaft. When other bearings are employed on the same shaft, they should

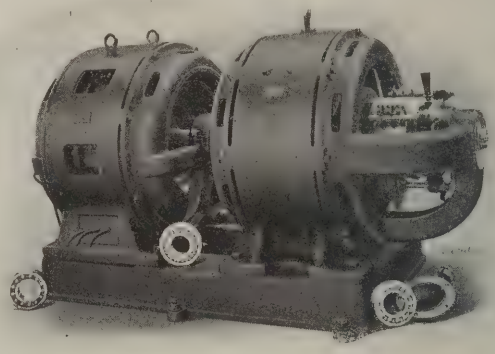


Fig. 6. Motor Generator Set Mounted on S. K. F. Ball Bearings.

be left free to move in their housings. This provision is made to allow for the elongation or contraction of the shaft due to changes in temperature or other causes.

6. Bearings must in all cases be protected from dirt, dust and dampness.

7. Ball bearings must always be lubricated. Excessive lubrication is not required, but the lubricant must be chemically neutral else the chemical action promptly attacks the highly polished bearing surfaces and entirely destroys the finish which is requisite to the successful operation of the bearing.

The above rules may be considered general for practically any application, and the diversity of the field in which ball bearings are now in service has substantially proven that they will hold for practically any condition.

S. K. F. Ball Bearings are now being extensively employed in the electrical field—on axle generators for train lighting systems, electric motors for power work, mining locomotive motors, electrically driven machine tools, high speed grinders and a variety of shop equipment such as is to be found in practically every railroad machine shop.

Manufacturers have come to appreciate that greater efficiency, saving in lubrication, greater cleanliness in operation, reduction in machine attendance costs, longer bearing life and extreme simplicity, are more and more in demand by those who are using factory and shop equipments.

To the shop superintendent they are a guarantee of better satisfaction, durability, lower production cost and increased production per given power unit over the plain bearing machines, and it may be said that of all the features which come the closest to those in charge of equipment the biggest of them is the saving in maintenance.

CONSOLIDATED TYPE "L" REGULATOR.

Bulletin No. 10 describes the new Consolidated type "L" regulator is of special interest. It will be recalled that this regulator is distinctive in that instead of varying the pressure on a pile of carbon blocks, the motion of the plunger in the controlling solenoid actuates a laminated rocker contact which engages contact segments of the resistance unit, cutting resistance in or out, as the case may be, by very slight rocking motion.

Electric Locomotives for the Southern Pacific Company

The accompanying illustration shows one of the new locomotives just being put into freight and switching service by the Southern Pacific Company. The total consignment includes 15 locomotives which are to be of the 50 ton type and will operate on either 600 or 1200 volt direct current. This locomotive when operating under natural ventilation will be able to exert a continuous draw bar pull of 5600 lbs., while with forced ventilation it can exert a continuous tractive effort of 11,520 lbs. for a period of one hour. With natural ventilation the locomotive will exert a tractive effort of 17,000 lbs. at a speed of 18.4 miles per hour on a 600 volt circuit and with forced ventilation it is capable of exerting a tractive effort for one hour of 21,600 lbs. at a speed of 17.6 miles per hour on a 600 volt circuit. Under favorable conditions the locomotive can exert a momentary tractive effort of 30,000 lbs.

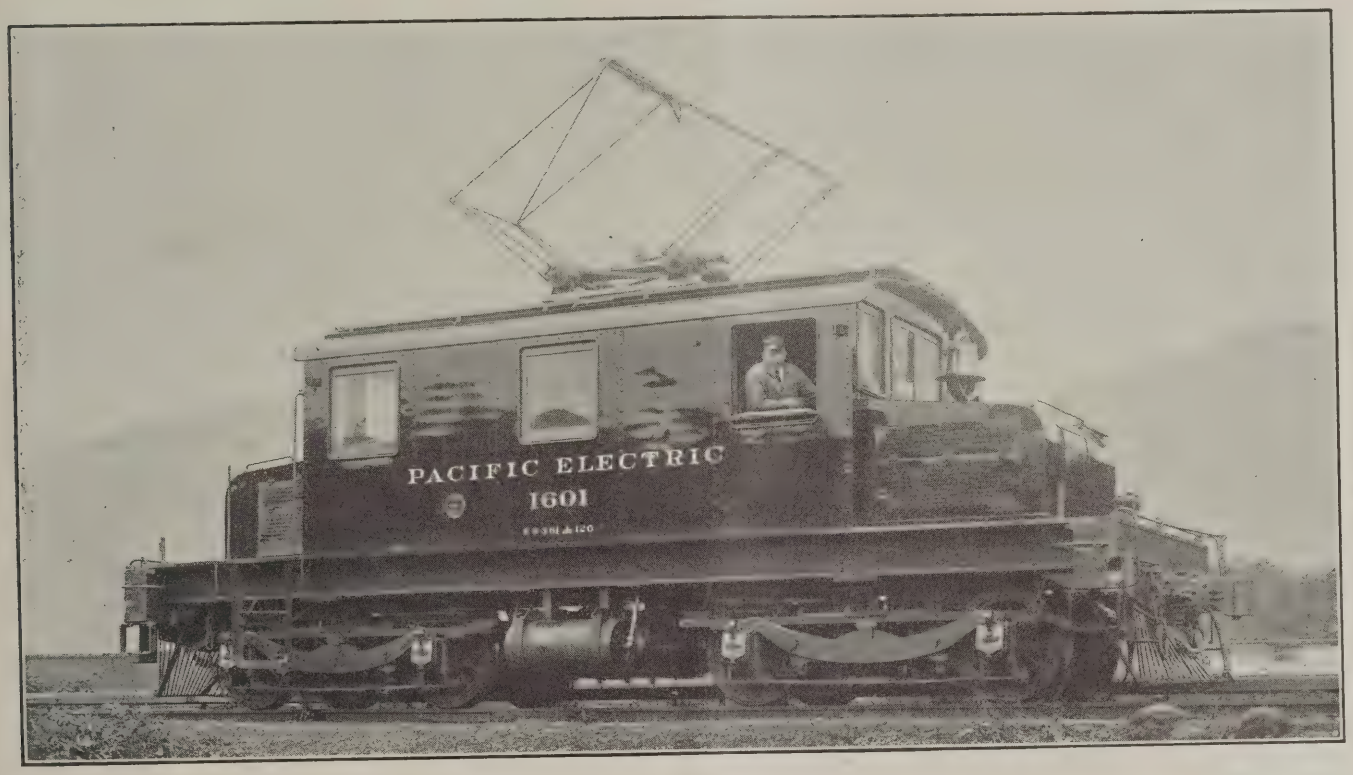


Fig. 1. New Electric Locomotive for the Southern Pacific Co.

The cab is built of steel 18 ft. long and 9 ft. 6 in. wide. It is arranged for double-end operation, and there are side steps at each end of the locomotive for the convenience of the switchman. There are four motors supplied each locomotive and each motor is geared direct to the axle as shown diagrametically below. These are exactly alike except that the No. 308-B-3 motor is wound for 1,200 volts, while the No. 308-B-7 is wound for 1,500 volts. The No. 308-B-7 motor has the same general characteristics as the 600 volt motor of the same rating, but is insulated for 1,200 volts. Its normal rating with natural ventilation is 225 horsepower at 600 volts with 315 amperes. With forced ventilation, the rating of the motor is 250 horsepower at 600 volts with 350 amperes. Its continuous rating with natural ventilation and perforated covers will be 140 amperes at 300 volts. With forced ventilation the continuous rating is 255 amperes at 350 volts.

These locomotives are built according to the most approved trunk line railway practice, and the main dimensions are as follows:

Track gauge	4 ft. 8½ in.
Wheel base, rigid	7 ft. 4 in.
Wheel base, total	25 ft.
Driving wheels, diam.—outside	36½ in.
Driving wheels, diam.—centers	31 in.
Journals	5½ in. x 10 in.
Distance between truck centers	17 ft. 8 in.
Width	10 ft.
Height to top of cab	11 ft. 6 in.
Length between couple knuckles	35 ft.
Weight	120,000 lbs.

The trucks are of the equalized pedestal type, the rectangular frames of which are forged in one piece. The pedestals are protected by shoes which can easily be replaced when worn out.

The Westinghouse unit switch control type HL is employed and there are three running positions provided for 600 volts and two for 1200 volts. A pneumatically operated switch has been installed which provides the three running positions, and this switch can be operated by a control from either end of the cab. It is so connected that the four motors of the car may be connected all in series, two motors in parallel and both pairs in series, or all four motors in multiple on the 600 volt circuit as desired. The master controller has 11 notches for the motors in full series, 9 notches with them in series parallel and 9 notches with the motors all in parallel on the 600 volts circuit. In changing over to operate on a 1200 volt circuit two hand operated drum type switches are installed which readjust the divisions in the main resistance and locks the series parallel switch in the series position. The master controller has the same number of notches available on the 1200 volt oper-

ation as under 600 volt operation for the full series and the full parallel position.

Each locomotive is equipped with train line receptacles and plugs so that any number of locomotives may be operated in tandum by a single engineer in the forward locomotive.

A special relay has been provided in addition to the standard control apparatus so that whenever a locomotive passes a certain point contact will be made which

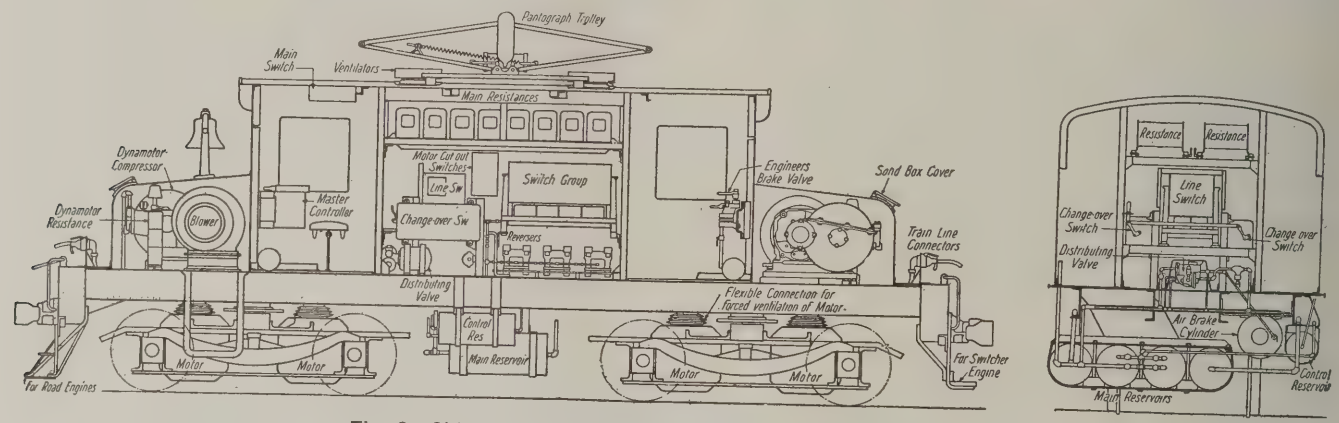


Fig. 2. Side View and Transverse Section through Locomotive.

will open all circuits of the motors. This insures that there can be no current through the motor when the trolley passes this point. In order to re-establish the connection through the motors, it is necessary to first bring the master controlled to the off position. A warning signal is located in the cab which notifies the motorman of an open switch due to overload circuit, blowing of the main fuse, etc.

For the air brake equipment there are two dynamotor compressors provided which have a capacity of 25 cubic feet of free air per minute. The dynamotor is virtually a double motor having a double set of field windings and a double set of armature windings on the same pole pieces and armature core. When the locomotive is operated on 1,200 volts the two windings are connected in series and the current for the lights and controller apparatus is tapped off across one motor winding, giving a voltage of approximately 600 volts. When operating on 600 volts one set of the armature and field coils will be cut out and the remaining set will operate as a series motor. The dynamotor runs constantly, there being a friction clutch pneumatically operated and controlled by the main reservoir pressure which drives the compressor whenever necessary; it automatically cuts out and stops the compressor when the pressure in the reservoir becomes of normal value.

There are two fans which supply forced ventilation to the main motors of the locomotive and these are mounted on extended shafts of the dynamotor. When the compressor is not in service, these fans furnish sufficient load for the series dynamotor to prevent it from running away when the main load of the compressor is removed.

The mechanical parts of the locomotive were built by the Baldwin Locomotive Works, while the electrical equipment was constructed and installed by the Westinghouse Electric and Manufacturing Co.

PLAN TO ELECTRIFY AT PHILADELPHIA.

It has been very recently announced the Pennsylvania will electrify the suburban section of its main line between Philadelphia and Paoli, Pa.

The present plan is to have this work completed in 1914 and the estimate of cost is $4,000,000.

RAILWAY LOAD FED BY A SUB-STATION RECEIVING POWER FROM A SINGLE-PHASE SOURCE.

The operation of a three-phase rotary converter railway system from a power house used primarily to supply single-phase current for the operation of a trunk line railroad is of more than passing interest.

The Stamford sub-station of the Connecticut Company is one of three rotary converter sub-stations now installed and designed for operation from the three-phase 11,000-volt, 25-cycle circuit fed from the Cos Cob power station of the N. Y., N. H. & H. R. R. Co. The other two are the Port Chester sub-station of the New York & Stamford Railway Co., with a capacity of 1,500 kw., and the White Plains sub-station of the Westchester St. R. R. Co., with a capacity of 1,200 kw. The Stamford sub-station contains three rotary converters (Fig. 1) rated at 300 kw. each, and with each rotary converter are three O. I. S. C. transformers (Fig. 1) and a suitable three-phase reactance.

In laying out this station a number of problems had to be considered: the resistance of the line between Stamford and Cos Cob was very low, the distance being only three and one-half miles, and the unbalancing of voltage due to the single-phase railroad system was considerable, as well as very fluctuating. Surges of voltage were for the same reason often encountered, and the conditions which would exist when one leg of the transmission line was opened had to be considered and provision made for them.

By providing sufficient taps on the 11,000 volt side of the transformers, it was found possible to reduce the maximum unbalancing of the line so far as the rotary converters themselves were concerned, to a value somewhere about one-half that on the primary circuit, and this arrangement, together with the reactance coils and liberal design of the rotary converters, has given very good results. In order to take care of the single-phase condition resulting from the opening of one leg of the transmission system, the specifications called for an equipment which would disconnect one leg and for rotaries which would be capable of carrying full load for five minutes being supplied with single-phase energy. The ability of the machine to do this has been amply demonstrated, there being only a slight momentary, and by no means objectionable, sparking when one leg is opened under conditions of full direct-current load. The disconnection of any one leg is obtained by the use of three single-pole, electrically operated oil circuit breakers on the incoming line, and by

means of undervoltage relays controlling the breakers in the power and trolley circuits, respectively.

The incoming three-phase 11,000-volt line is controlled by single-pole, outdoor type electrically operated oil circuit breakers similar to those used on the bridges of the electrified portion of the N. Y., N. H. & H. R. R., but they are set at a rather high tripping point, so that under normal conditions the station is

Fig. 1. Interior of Stamford Sub-Station.

handled and overload protection afforded by electrically operated Westinghouse type E oil circuit breakers mounted in the bus-bar structure in the building. These are operated and tripped from power supplied by a storage battery in the station.

The switchboard consists simply of a small panel for control of the outdoor type single-pole oil circuit breakers.

Lightning protection is afforded by a specially designed electrolytic arrester.

After being in service a period of over a year, it does not appear that there is any difficulty in obtaining successful operation of a rotary converter substation feeding a railway load. Careful consideration was given to the various points by the engineers of the Connecticut Company and of the Westinghouse Electric and Manufacturing Company, and no change has been found necessary in the plans adopted before the installation of the apparatus. It is interesting to note that under the new arrangement of connections now being installed by the engineers of the N. Y., N. H. & H. R. R. Co. the requirements of single-phase operation of the rotaries will not be necessary in contemplated sub-stations, as this condition will not then arise.

A NEW SYSTEM OF ELECTRIC WIRING.

A system of wiring introduced by the Western Electric Co. of London, England, seems to offer some advantages in the way of cheapening the cost of open wiring installations about 40 per cent. This is known as the Terroid system and is made up of one wire well insulated with high grade rubber compound, on the outside of which is twisted the wire for the return circuit, having a very low grade insulation or none at all.

The return side of the circuit is grounded so there will be no trouble from the lack of insulation on the outside wire.

The electrical circuit is completed in the principal conductor, through the switches and fuses of the lights, motors or other current-consuming devices, and back by the return or earthed conductor. This is an ingenious application of an old principle which is adopted, for example, in electric railways, where the third rail or trolley wire is insulated, the car wheels running on the return conductor.

In electric lighting on the three-wire system, the middle wire is earthed and current of 120 or 250 volts pressure returns by the middle wire. For private installation a separate bare conductor acting as a return wire was in use in some places in England more than 20 years ago. It was usually run in soft metal pipes, but frequently it was installed without mechanical protection. In either case it was liable to breakage, involving the passage of the return current through foreign paths, which sometimes produced not only a breakdown of the electric supply, but occasionally resulted in electrolytic damage. This system, however, fell into disuse before the general introduction of iron and steel conduits.

The Terroid system combines the principal and the return conductor in one cable and thus casual earthing is prevented. For conduit work the combined wire is smaller than two insulated wires and therefore the pipes which can be used are smaller and there is not so much cutting away of wood work and walls to allow the passage of the pipes. This is a most important point in interior installation work. Other advantages of the system are that no special tools are required to carry out the work and it can be used for the extension of an existing installation as easily as for a new one, and also it can be applied to either alternating or direct current, conduit or casing work or open wiring.

DIRECT CURRENT RAILWAYS.

There has been recently issued by the General Electric company an attractively bound book of 132 pages, devoted to the use of the "higher voltages" in the operation of Direct Current Electric Railways. The bulletin sets forth the advantages of the "higher voltages" in this connection. It contains numerous tables comparing the various costs of 1200 volt systems as compared with those of 600 volts, illustrates and describes station and car equipments, locomotives for railroads of higher direct current voltages, and describes the various systems employing direct current at 1200, 1500 and 2400 volts. The bulletin contains a large amount of information both of interest and value to electric railway operators.

The number of this publication is 4958.

New G. E. Bulletins.

The General Electric Company have just issued a new bulletin on type "R" single phase motors which supersedes their previous bulletin on this subject. This covers both the theoretical design, application, general description and detail of parts. They have also just issued a new bulletin on their type "W" long burning flame arc lamp. This lamp is designed to operate on alternative current series circuits. They have also just issued a bulletin on direct current motor starting and regulating panels.

ELECTRIFICATION OF ANOTHER ENGLISH RAILWAY LINE.

The North Eastern Railway Company has decided to Electrify its mineral line between Shildon and Newport, near Middleborough, England. This distance is 18 miles.

Lighting Fixtures for Postal Cars

The standardization of the railway postal car, resulting from the specifications issued by the U. S. Post Office Department, and the illumination requirements called for in these specifications, do not cover any particular type of fixture that must be used. The question of meeting the illumination values specified is largely dependent on the type of lamp, the reflector and the location and mounting height of the light units. The type of fixture employed is a question largely governed by the individual preference of the different railways, but there are several features that should govern the selection of the lighting fixture.

First, the method of wiring the car is an important consideration. It is generally considered preferable by most railway lighting experts that conduits located inside the car are more accessible and that this method of wiring involves the lowest cost of maintenance. Nothing in the operation of a railway postal car argues against the use of this method of wiring.

Fig. 1. The Safety Co.'s Electric Lighting Fixture for Bag Racks and Storage.

Second, the selection of the type of electric lamp and the type of reflector to be used calls for a fixed relation between the lamp and reflector. Future experience may prove that the first choice of lamps and reflectors was not best suited to the service, or possibly improvements in the art of lamp and reflector manufacture may be made. It is, therefore, important that some provision be made for these future contingencies in the selection of the lighting fixture.

Third, the accessibility to the electric wiring afforded by the construction of the fixture, since this feature involves the cost of maintenance.

Fourth, the mechanical construction of the fixture, insuring the successful and economical installation and operation of the lighting service.

During the tests on the Baltimore and Ohio postal car at Washington, which resulted in the illumination values contained in the Post Office Department Specifications, the Safety Car Heating & Lighting Company supplied the type of fixture designed especially for these tests, and which provided for an adjustable mounting height of the lamp in the reflector as well as an adjustable height of the lamp from the floor. Such a type of fixture answered every purpose of the tests, but it was not intended for regular railway service, since an adjustable mounting height is very apt to be adjusted by someone who is not familiar with the exact requirements. This company has since developed a line of electric fixtures designed for postal car service, which supply all the essential requirements enumerated in the previous paragraphs.

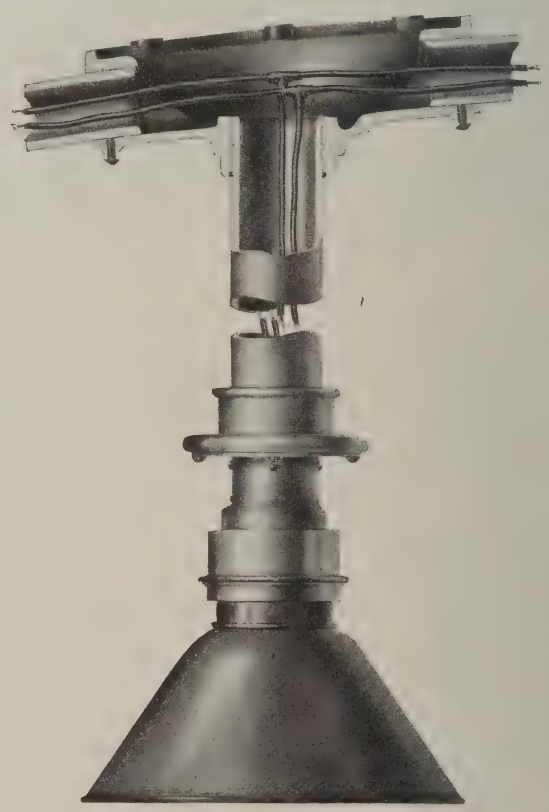


Fig. 2. The Safety Co.'s Electric Lighting Fixture for Letter Cases.

These fixtures comprise a reflector, a shadeholder and a stem and base support. The base is designed for inside conduit wiring, and is supplied for either one or two outlets for either ½ inch, ¾ inch, or 1 inch conduit.

The shadeholder is a form of the "Safety Shadeholder" designed particularly for the interchangeable lamp positions necessitated by the use of various sizes and wattage lamps as well as different types of reflectors.

Considering the various types of electric lamps and the various types of reflectors, it is necessary to provide for a number of different positions of the lamp in relation to the reflector. To provide a fixture wherein not only the position selected for the original installation of lamps and reflectors is maintained, but at the same time provide for a change in the type of lamp or

reflector without a change in the fixture, is a problem that has been solved by these types of fixtures designed by the Safety Car Heating & Lighting Company.

Where consideration must be given to the various types of lamps, various reflectors and various size conduits with the number of combinations involved in the use of same, it is important to those selecting lighting equipment that a comprehensive system of designating the complete fixture be available. The Safety Car Heating & Lighting Company has assigned an identification number to a complete fixture, which is easily understood, and conveys to those ordering this material the exact purpose to which the fixture is to be applied. The shadeholders are designated by a letter signifying the mounting height of the lamp in the reflector, and this shadeholder, when ordered with a reflector, is designated by this letter and the last two numerals of the catalogue number applied to the reflector. The base and stem of the fixture are classified according to the size of the conduit to be used and the number of outlets required; a letter applying to the size of conduit and a suffix numeral to the number of outlets. In ordering a complete fixture the catalogue designation or number consists of the letter applied to the shadeholder, the last two numerals of the complete reflector number, the letter designating the size of conduit, and the numeral indicating the number of outlets required. As an illustration, if a fixture is required for use in a postal car at the letter case, wherein a G-30, 50 watt lamp is to be employed, and the wiring is run in a ¼ inch conduit, by reference to the accompanying table it will be noted that with the 50 watt lamp for letter case lighting, it is necessary to use reflector No. 18470, and the mounting height for this combination of lamp and reflector is 1⅜ inches above and requires a type "A" shadeholder. The designation of this fixture would therefore be A-70-Y-1 or A-70-Y-2, according to whether one or two outlets are required for the conduit.

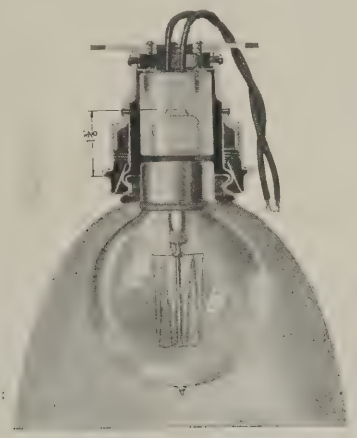


Fig. 3. Type "A60" Holder.

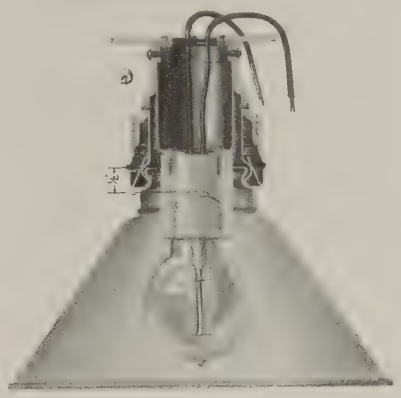


Fig. 4. Type "F70" Holder.

SOME NEW PRACTICAL BOOKS.

The Joseph G. Branch Publishing Company of Chicago have just announced the publication of three new books which will be of special interest to our readers.

The titles of these books are as follows:

"Alternating Current Simplified," by Burns.

"Electric Motors," by Burns.

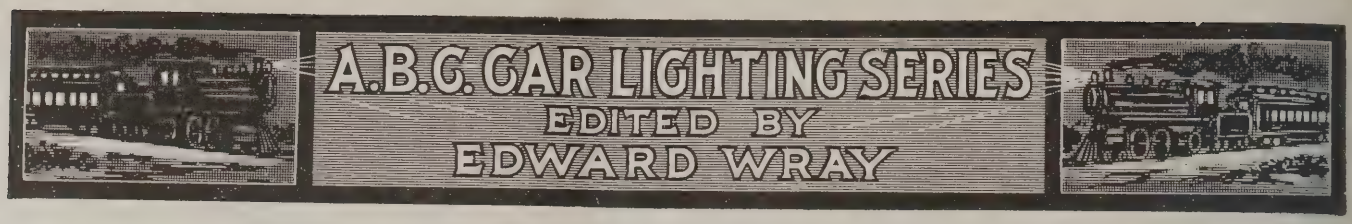
"Practical Mathematics," by Burns & Branch.

These books are written in very simple terms and get right down to brass tacks, so that they are a mighty valuable thing for an electrician to have and make a study of. The first two books retail at $1.50 and the last one at $1.00.

Lamps, Reflectors, Position of Lamp in Reflector, Location of Light Unit in Car and Designation of Complete Lighting Fixtures for Postal Cars and Postal Apartment Cars to Conform to Post Office Dept. Specifications.

Type and Wattage of Lamp	Reflector Number	Relation of Lamp Base Contact to Top of Reflector	Adjustment or type of Holder	Where used in Postal Car	Catalog Number, Including Holder, Reflector and Base. One ½" outlet	Two ½" Outlet	One ¾" outlet	Two ¾" Outlets	One 1" Outlet	Two 1" Outlets
50 w. G-30	18470	1⅜" above	"A"	Let. Case	A 70 X¹	A 70 X²	A 70 Y¹	A 70 Y²	A 70 Z¹	A 70 Z²
50 w. G-30	18460	1⅜" above	"A"	B.R.&S.*	A 60 X¹	A 60 X²	A 60 Y¹	A 60 Y²	A 60 Z¹	A 60 Z²
50 w. G-30	18461	1⅜" above	"A"	B.R.&S.	A 61 X¹	A 61 X²	A 61 Y¹	A 61 Y²	A 61 Z¹	A 61 Z²
25 w. S-19	18440	1" above	"B"	B.R.&S.	B 40 X¹	B 40 X²	B 40 Y¹	B 40 Y²	B 40 Z¹	B 40 Z²
25 w. S-19	18441	1" above	"B"	B.R.&S.	B 41 X¹	B 41 X²	B 41 Y¹	B 41 Y²	B 41 Z¹	B 41 Z²
40 w. S-19	18470	⅝" above	"C"	Let. case	C 70 X¹	C 70 X²	C 70 Y¹	C 70 Y²	C 70 Z¹	C 70 Z²
40 w. S-19	18460	⅝" above	"C"	B.R.&S.	C 60 X¹	C 60 X²	C 60 Y¹	C 60 Y²	C 60 Z¹	C 60 Z²
40 w. S-19	18461	⅝" above	"C"	B.R.&S.	C 61 X¹	C 61 X²	C 61 Y¹	C 61 Y²	C 61 Z¹	C 61 Z²
25 w. S-17	18440	½" above	"D"	B.R.&S.	D 40 X¹	D 40 X²	D 40 Y¹	D 40 Y²	D 40 Z¹	D 40 Z²
25 w. S-17	18441	½" above	"D"	B.R.&S.	D 41 X¹	D 41 X²	D 41 Y¹	D 41 Y²	D 41 Z¹	D 41 Z²
25 w. S-19	18470	½" above	"D"	Let. case	D 70 X¹	D 70 X²	D 70 Y²	D 70 Y²	D 70 Z¹	D 70 Z²
25 w. S-17	18470	even	"E"	Let. case	E 70 X¹	E 70 X²	E 70 Y¹	E 70 Y²	E 70 Z¹	E 70 Z²
25 w. G-18½	18440	even	"E"	B.R.&S.	E 40 X¹	E 40 X²	E 40 Y¹	E 40 Y²	E 40 Z¹	E 40 Z²
25 w. G-18½	18441	even	"E"	B.R.&S.	E 41 X¹	E 41 X²	E 41 Y¹	E 41 Y²	E 41 Z¹	E 41 Z²
15 w. G-18½	18440	even	"E"	B.R.&S.	E 40 X¹	E 40 X²	E 40 Y¹	E 40 Y²	E 40 Z¹	E 40 Z²
15 w. G-18½	18441	even	"E"	B.R.&S.	E 41 X¹	E 41 X²	E 41 Y¹	E 41 Y²	E 41 Z¹	E 41 Z²
25 w. G-18½	18470	½" below	"F"	Let. case	F 70 X¹	F 70 X²	F 70 Y¹	F 70 Y²	F 70 Z¹	F 70 Z²
15 w. G-18½	18470	½" below	"F"	Let. case	F 70 X¹	F 70 X²	F 70 Y¹	F 70 Y²	F 70 Z¹	F 70 Z²

*Bag Racks and Storage.



LESSON No. 15

Head-end System

The Gould Booster System.

Some of the boys may feel that we are making a mistake when we take our valuable space and their valuable time in describing the details of certain equipments which are either superseded or not being operated at the present time. This course of study, however, is to *educate* ourselves in all matters of railway car lighting and not simply one of learning a lot of thumb rules regarding car lighting apparatus. Both of the equipments described in this lesson are used only to a very limited extent if at all at the present time, but they contain many features which are of special interest to the student of electric car lighting.

The Gould booster system was designed by the Gould Coupler Company and placed in service on four trains of the Pennsylvania railroad in 1907. As is well appreciated in all head-end operation today there must be some special provision made for charging the storage batteries (32 cells of battery on discharge have a voltage ranging from 66 volts at the beginning of discharge to 57 volts at the end of discharge) so the lamp voltage is taken at a fair average and 63 volt lamps are used. On charge the batteries require from

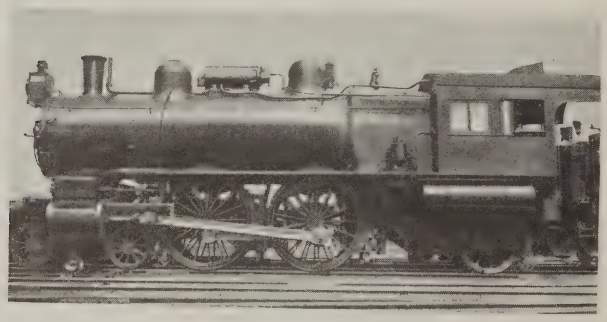


Fig. 81. Side View of Locomotive Showing Turbo Generator.

80 to 85 volts to charge them up to full capacity with normal charging current flowing, and it is very obvious that if this voltage is impressed on the lamps it destroys them in a very short time. Therefore, in order to charge the batteries to full capacity and still maintain the lamps at normal voltage, the Gould booster system was developed.

It will be interesting to review the other types of head-end systems and note how the batteries are charged to full capacity without straining the lamps in each case. (*See lesson No.* 10, *November,* 1912; *lesson No.* 11, *December,* 1912; *lesson No.* 12, *January,* 1913, *and lesson No.* 13, *February,* 1913.)

The turbo generator set is mounted on the locomotive as shown in the accompanying illustration and operated at full boiler pressure. This requires steam nozzles as described in last month's lesson being redesigned for this higher pressure. The generator was supplied with both interpoles, to prevent shifting of the field on overload (*see lesson No.* 2, *March,* 1912), and a compound winding on the main field of the generator which causes the generator to give 67 volts at quarter load and 73 volts at full load. This rising voltage characteristic was considered necessary in order to care for the voltage drop in the return negative main from the rear of the train to the generator. This gives about 66 volts on the lamp circuits at all times whether at full load or at light load.

On some engines the turbine has been mounted on top of the boiler, lengthwise between the steam and sand domes. This is a very much better position than when mounted crosswise in front of the stack as shown, for in the latter case the gyroscopic action of the turbine revolving at high speed might cause se-

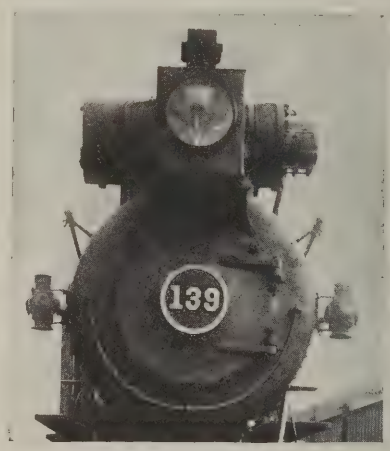


Fig. 82. Turbo Generator Mounted Cross-wise in Front of Stack.

vere strain and wearing on the bearings as the engine sways from side to side when traveling at high speed.

The booster is mounted on the locomotive tender as shown in Fig. 83 on the next page. This consists of three machines, a differentially wound booster, a compound wound motor and a series lamp booster, all direct connected on the same shaft. The generator operates so as to deliver constant voltage, the slight rise on full load being only such as is necessary to overcome line drop in the return negative main. The battery booster increases the voltage in the battery circuit by just the proper amount to charge the storage batteries. If a very large number of lamps are turned on the battery charging current is automatically reduced to low value, so that the generator will not be over loaded. As the lamp current decreases, however, the battery current is automatically increased providing the batteries need the charge. The combined voltage of the generator and the booster furnishes the necessary battery charging voltage.

By referring to the wiring diagram, Fig. 85, the detail of these connections may be observed. (B) is the battery booster, (M) the compound wound motor and (L) the lamp booster. It will be noted that the battery booster has both a shunt field and two series fields. One of these series fields carries the battery charging current and is wound so as to oppose the magnetism of the shunt winding, which is the larger

of the two. The other series winding of the booster carries a certain portion of the total lamp current. The magnetism of this lamp current coil also opposes the magnetism of the main shunt winding, and when a heavy lamp load is being carried by the generator the current flowing through this coil nearly balances the shunt coil magnetism, so that the battery booster voltage will be practically zero: the battery is then simply floating across the line. If the generator is overloaded, the current through this lamp series coil will reverse the field magnetism of the bucker and may actually cause a current to flow from the battery back to generator positive which will assist in carrying the load.

If the lamp load is very light or entirely off, there will be little or no current flowing through the lamp series coil. The main shunt winding of the booster field is sufficient to develop about 20 volts when the booster armature is rotating at normal speed. The battery current through the series coil, however, op-

Fig. 83. Showing Booster on Locomotive Tender.

poses the magnetism of the main shunt coil and with normal charging current flowing, it may cut this booster voltage down to 5 or 6 volts, just enough to raise the voltage in the battery circuit to proper value. As the battery counter electro motive force rises as the charge proceeds, the battery current will taper off slightly, but this will cause a decrease in the opposing magnetism of the series coil and allows the shunt magnetism to become more effective, raising the battery booster voltage. At the end of charge the battery current will have tapered off to a minimum and the battery booster voltage will have automatically risen to nearly full value of 18 to 20 volts. The voltage impressed across the battery circuit is at all times the sum of the generator voltage and the voltage in the battery booster armature.

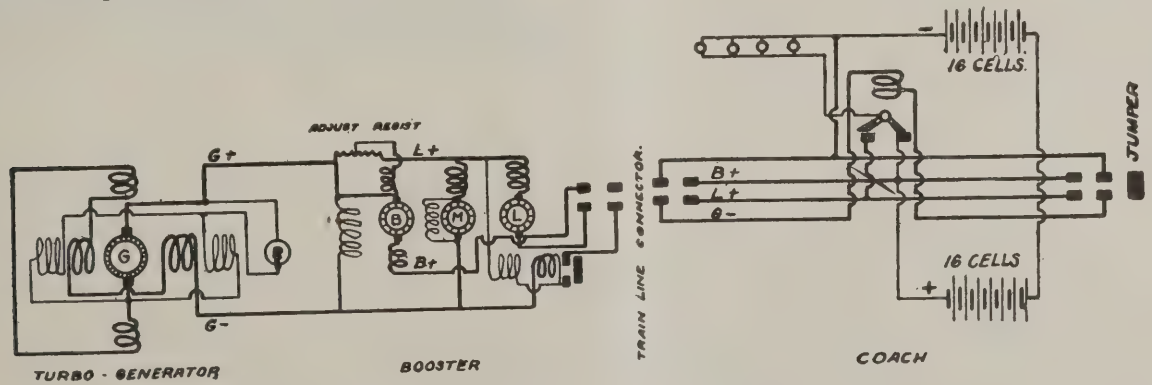
As the batteries become nearly charged, and the charging current tapers off, the load on the booster motor will be reduced and since this is a compound wound motor (the series field and the shunt field magnetism acting in the same direction) the motor will speed up as the load falls off. This will tend to help out in raising the battery booster voltage at the end of charge. Similarly, if the battery booster is overloaded due to low batteries, the speed of the com-

Fig. 84. Train Line Connector Between Cars.

pound wound motor will automatically slow up on this overload and so assist the battery series winding of the booster in cutting down the battery booster voltage.

The lamp booster is connected in series with the line and all of the lamp current passes both through this armature and series field. The voltage developed in the lamp booster will then increase directly with the increase in lamp load, and is so adjusted as to maintain a regular distribution of voltage regardless of train lengths and the distribution of the load.

To operate this equipment it is simply necessary to open or close a steam valve in the locomotive cab. As the generator voltage builds up the booster motor starts as it is connected right across the generator terminals. When the generator voltage reaches 64 volts, the automatic switch on the rear of the engine tender closes and current will then pass through the train line wires, picking up the transfer switches in each car. This breaks the direct connection on each car between lamps and battery as shown in the wiring diagram. The turbo generator set on the engine will



GOULD BOOSTER - SYSTEM.

Fig. 85. Wiring Diagram.

then provide lamp current which passes through the adjustable shunt and lamp current coil of the battery booster, through the series coil and armature of the lamp booster, thence through the lamp circuits in the various cars, returning through the lifting coils of the transfer switch on the negative side of the line, to the automatic switch located on the rear of the engine tender and thence to the generator negative. The battery charging current flows from the generator positive through the train line to the positive side of the batteries and returning from the rear of the train through the train line and lifting coils of the transfer switches, to the automatic switch and generator negative.

When the turbine is shut down it is only necessary to close the steam valve when the reverse action takes place; then the current through the lifting coils of the transfer switches falls to a certain minimum value, these switches all drop, connecting the lamp circuit of each car across its own battery. As the generator voltage falls still lower and a slight reversal of current occurs, the main automatic switch on the tender opens, disconnecting the turbine equipment from the balance of the train line.

Axle Lighting.

Safety Equipment Type "A."

The axle equipment described this month is the original equipment developed by the Safety Car Heating and Lighting Company in 1909. Some of the parts of the equipment have given such satisfactory operation that they are used in the latest equipment of that company. The frame of the generator was a large steel casting of the barrel type having four cast poles and laminated pole shoes provided with cast iron heads. The armature coils were made up of asbestos covered wire, boxed and impregnated and held in the slots by hard maple wedges.

The field coils in this early equipment were treated with a vacuum impregnating process which made them oil and moisture proof. The pole changer was of a mechanical type, the brush rigging being mounted on a ball bearing rocker so that it is free to rotate between two stops 90 degrees apart. The friction of the brushes against the commutator causes the reversal of this rocker when the direction of the train motion is reversed. The positive brush then comes to the same point that the negative brush had previously been, and vice versa so that when the generator revolves in the reverse direction the positive brush will make contact with the positive position on the armature.

The automatic switch is of a type similar to that described in our Dec., 1912, issue, consisting of a shunt and series coil wound on the same spindle, leaving an iron plunger with contact bar across the bottom.

This generator field regulator was one of the first to employ the carbon disc placed in series with the generator field and this part of the equipment is of practically the same construction in the latest equipments manufactured by this company. Two sets of carbon discs (see Fig. 88) are compressed firmly by the pull of an adjustable spring (G) which is mounted midway between the two piles of carbon discs so that this pressure bears equally on each. The field current passes through these two carbons in series as shown by the dotted line. If the automatic switch has closed, the magnetic pull of the coil (S) downward on the iron plunger (P) acts through a lever to lessen the pressure of the spring (G) on the carbon discs. This increases the resistance of the two piles of carbon discs and so decreases the generator field current.

It will be noted from the wiring diagram that the coil (S) is connected in series with the storage battery, so that after the main switch is closed a slightly further increase of train speed will bring the battery current up to the proper value and any further increase of current, due to increased train speed, flowing through coil "S" of the regulating solenoid, will pull the plunger "P" further into the coil, thus reducing the pressure on the carbon discs and so reduce the field strength to such an extent that this current will again become normal. If a slightly lower train speed is encountered, the reverse will take place. The plunger "P" being drawn out of the coil "S" by the spring "G,"

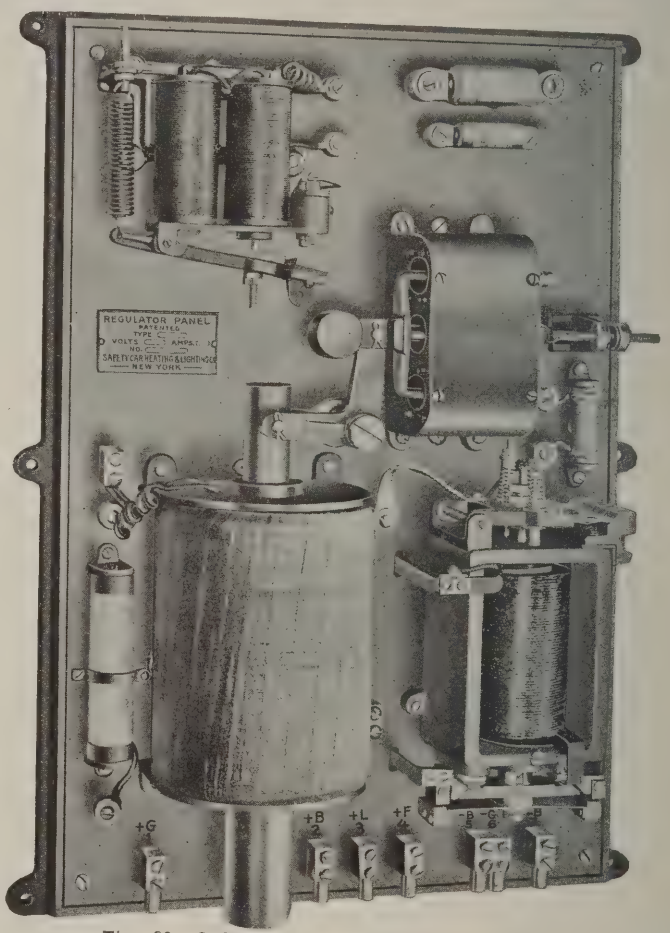


Fig. 86. Safety Type "A" Regulator Panel.

thus strengthening the field and bringing the current back to normal. It is claimed that the total regulation between 20 and 80 miles an hour is accomplished by a movement of about ⅛ of an inch of the plunger, so that it can be readily seen that the carbon resistance is very sensitive. As the lamp current is entirely independent of the battery current, the batteries are always being charged at some predetermined rate, whether the lamps are being lighted or not, this lamp current being taken from the generator direct. The batteries are protected from over-charge by a battery cut-off switch, so that when the E. M. F. across their terminals rises to some predetermined amount, the generator field strength is so reduced that the batteries practically float across the generator. This switch also serves to protect the system, if an open circuit in the battery occurs.

Upon referring to the wiring diagram, Fig. 88, it will be seen that when the battery cut-off switch (T) operates it makes a connection through the fine winding (A) of the main regulating coil. The magnetism

of this coil is in the same polarity as the magnetism of the coil (S) and so increases the pull on the iron plunger (P) that the generator voltage is cut down to a comparatively low value and the battery current through the coil (S) is greatly reduced. As a matter of fact, the magnetism of the coil (A) simply replaces

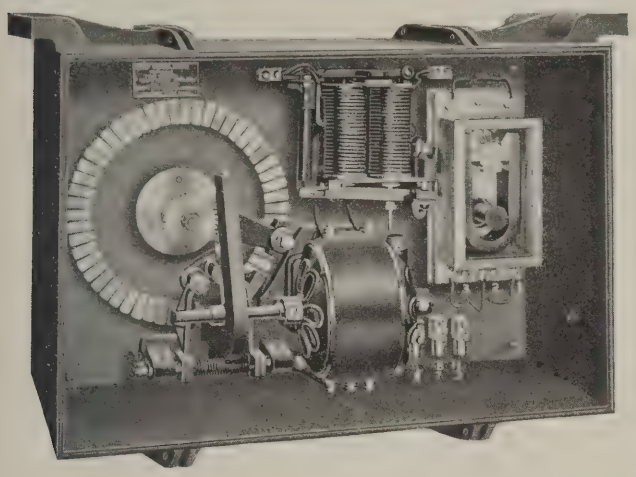


Fig. 87. Safety Type "A" Lamp Regulator.

an equal amount of magnetism provided by the coil (S) and the current of the coil (S) creating that magnetism is correspondingly reduced.

In the case of a broken battery connection, the generator voltage would rise on account of no current flowing through the series regulating coil (S) until it had risen to the point at which the battery cut-off switch was adjusted to operate, when this switch would close and energize the shunt coil (A); the regulator would then act as though the battery had reached a fully charged condition. In this case the generator regulation is nearly that of constant potential and the turning on and off of the lamps does not affect the voltage of the machine. When the car comes to rest, this battery cut-out switch will open, thus it will be seen that if no current is used for lamps during this stop, the battery cut-out switch will again close shortly after the train has reached the cutting-in speed. If current has been used for lamps at this stop the generator will again begin to charge the batteries until such time as the battery voltage again rises, when this switch will act and the cycles again repeat. If, as before mentioned, there is an open circuit in the batteries, this switch will close almost immediately after the train has reached the cutting-in speed and the lamp current will be furnished from the generator direct as before. The resistance "Q" is variable, so that if it is not desired to have the battery charge brought to zero, it can very easily be accomplished by varying this resistance.

The lamp regulator possesses some new features which are original with this equipment. This regulator consists of a rheostat in series with the lamps, the rheostat being operated by a motor which is controlled by a special voltmeter relay. The motor is series wound, having its field coils opposed. The relay is a special Weston voltmeter movement, provided with special heavy jewelled bearings to withstand the shocks and vibration of railroad service. In place of the usual pointer which moves over the scale of a voltmeter, there is a light rod on the end of which is a thin piece of spring platinum-iridium. On each side are contacts tipped with small balls of this same material. The change of a fraction of a volt will cause this pointer to make connection with either one or the other of these side contacts, which short circuits one of the field coils, allowing current to flow through the armature, this short circuit and the other field coil which will cause the motor to operate.

If lamps are burning there is always current in this motor, but the motor will not operate owing to its opposed field coils until one or the other of these field coils is practically cut out. A switch on the regulator through which the lamp current passes is provided so that if there are no lamps on, the motor and relay are dead and the resistance in circuit is that which was last correct for the lamps then burning.

When any number of lamps are again turned on, the resistance will probably be nearer correct than if the motor were allowed to operate until all the resistance was cut in. Referring to wiring diagram, Fig. 88, it will be seen that the lamp current is taken from the right hand contact of main switch "H," which is positive, through the lamps to post marked "Negative

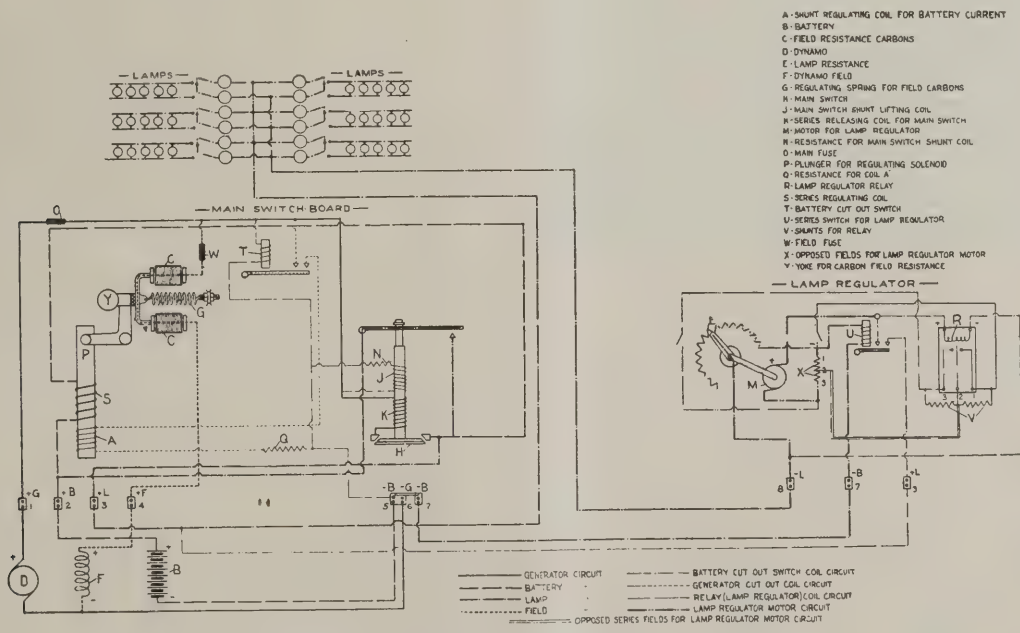


Fig. 88. Wiring Diagram of Safety Type "A" Equipment.

L No. 8," through resistance "E," switch coils "U," to post "Negative B No. 7," thence back to the generator. Current passing through coil "U" energizes this switch, closing the connection between the two contacts. The voltmeter movement is connected across the lamp mains, through these contacts and when the switch is closed the positive motor contact is also made. If the voltage on the lamps is higher, connection is made between the points of the voltmeter relay Nos. 2 and 3; this short circuits one field, so that the motor runs in such a direction as to put resistance into the lamp circuit until the voltage on the lamps again becomes normal, when the pointer will resume its central position and the motor will cease to operate. When the lamp voltage is below normal, connection is made between posts Nos. 1 and 2, short circuiting the other field coil and the motor will then operate in the other direction to take out resistance.

Thus it will be seen that only when the voltage on the lamps changes does the motor operate. The connection between the pointer and the side contacts is a wiping one, so that good contact at this point is always assured. Resistance coils "V" are placed in shunt across the terminals Nos. 1, 2 and 3 of the relay, so as to reduce the amount of current flowing through these relay contacts.

Whenever the rheostat arm is moved around in either direction to its extreme, it engages pivoted arms which make connection between the motor field coils and posts, Nos. 1 and 3 on the relay. The opening of either of these contacts breaks the circuit of the connection made to operate the motor in that direction and thus stops the motor. The connection on the other side not being broken, the motor is free to operate in the other direction. The resistance coils on the back are exposed and are of separate pieces, so that if they should become broken or burned out, they can very easily be replaced. The melting point of the wire used for this resistance is about 2,700 degrees Fahr. When the car is at rest current for the lamps flows from positive battery to the auxiliary contact on top of main switch and thence to the lamps.

(*Car Lighting Lessons to be Continued Next Month.*)

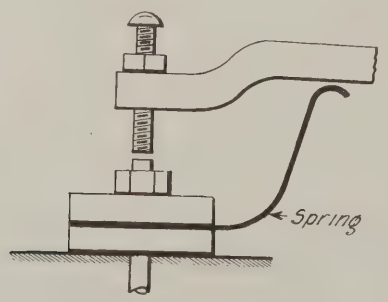
Practical Stunts

(*Send in your ideas—we pay for them.*)

Short-Circuiting Contact on Auto Switch.

After reading some of the practical stunts that have appeared from time to time I thought I would offer the following:

Quite often the Bliss automatic switch short-circuiting lever fails to make proper contact, either due to dirt having collected under the contact where sharp screw in the short-circuiting lever has pounded a hole or to any other cause which does not always permit the screw to come in contact with the small hole on the top of the switch. When this happens I have known the voltage to run up as high as sixty to seventy volts, causing the taper charge or stop charge to work, thus preventing the machine from working. In order to overcome this difficulty the Santa Fe has constructed a wiping brush contact out of phosphor bronze (like sketch enclosed) which is placed under the two small nuts at the top of the switch and a good clean contact is thus insured. I am enclosing sample of this contact.

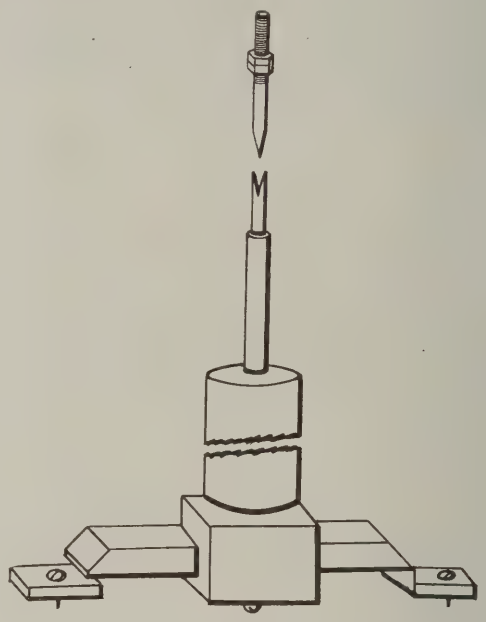


Short Circuiting Spring for Auto Switch.

The short-circuiting lever at the top of the Bliss automatic switch short-circuits the resistance which is in series with the lifting coil. A. E. Voigt.

Repairing Auto-Switch Plunger.

The other day I had a car arrive with the top of the automatic switch plunger burned off, caused by grounding the top contact arm on the plunger. Having no new ones in stock, I devised an efficient means of repairing same. With a knife-shaped file I cut a V-shaped slot in the small part of the rod that was left on the plunger and cut the head of a 3x3/16 in bolt and filed it so it would fit in the V-shaped slot. I then drilled a hole through both and put a pin through to hold them together. As an extra precaution I soldered the joint and made a job just as good as a new plunger could have been. George Greve.



Showing Method of Repairing Plunger.

Auto-Switch Spring.

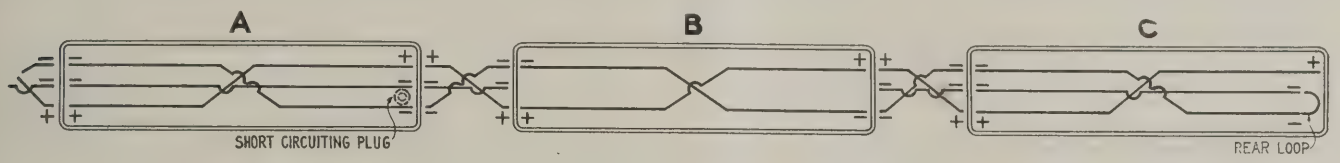
For a long while I have been puzzled over cars coming in having main fuse blown on a type D Consolidated, and upon testing out generator found everything to be in first-class condition. I discovered recently while testing the lights in a car, that just as the yard engine coupled on, which it did with quite a jar, the lights got dim for about a second and then brightened up again. Upon investigation I found my main fuse blown. It seems that the jar of the coupling caused the automatic switch to jump up and, by short-circuiting the battery through the dead generator, blew the fuse.

Now I have applied a stronger detention spring on the automatic switch which will allow it to come up a short way before touching the spring, but will not go all the way in without overcoming the resistance of the stronger spring. This does not affect the jumping in voltage of the automatic switch, as the arm can

rise a short way before encountering any resistance and then the shorter air space will greatly increase the magnetic lines of force, allowing it to overcome the increased tension of the spring. Since doing this I have had a very large reduction in the amount of blown fuses. GEORGE GREVE.

Battery Charging Stunt.

On headend trains having a storage battery on the last car it sometimes occurs that Pullman cars are picked up enroute equipped with only two train line wires. An electrician might think that since he had no negative loop wire back to the battery in the last car that it would be impossible to light this car from the headend set; but if you turn up the thumb screw shown above on the rear connector of the car (a) just ahead of the two wire Pullman car (b), this will establish a connection from the negative loop to the negative outside train line, just as is done by the rear loop of the last car (c). If a two or three wire connector between (a) and (b), and the two or three wire connector between (b) and (c) is put up, the train circuit of car (a) and the other cars ahead will be on an ordinary three wire train line circuit, but the last two cars will feed back over the positive and negative outside wires as a simple two wire circuit to the lamps and the storage battery in car (c).—O. S. Jeffries.



Train Line Showing Connections when Two Wire Car is Inserted in Train.

Generator Foot Clamp.

Some trouble has been experienced with the cap screws used in holding the foot clamps on Bliss dynamos breaking off. If both clamps on one loop are off, the loop can be pulled or jolted from under the dynamo, allowing it to drop down on the road bed. If this happens when the train is enroute a serious accident would undoubtedly result.

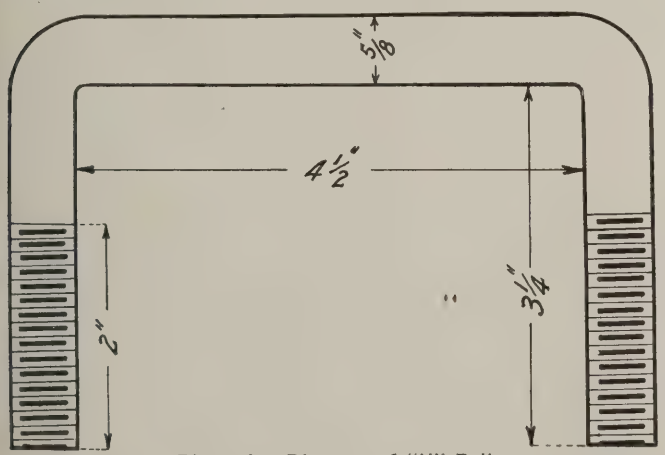
The Santa Fe engineers have devised a foot clamp that seems to remove this difficulty. The foot clamp and U bolt are both shown in detail with dimensions and as applied to a generator, in the accompanying illustrations. Dimensions given are correct for types (M) and (O) U. S. L. generators.

Both clamp and U bolt should be made on a bull-dozer as it is necessary to have them properly formed in order to give satisfaction when applied. As long as one U bolt is in place the loop cannot be pulled from under the dynamo.

The cost of making this clamp is very small and it is easily applied. The operation on a number of our equipments has shown it to be very satisfactory.

S. W. Everett.

View of Foot Clamps in Service.

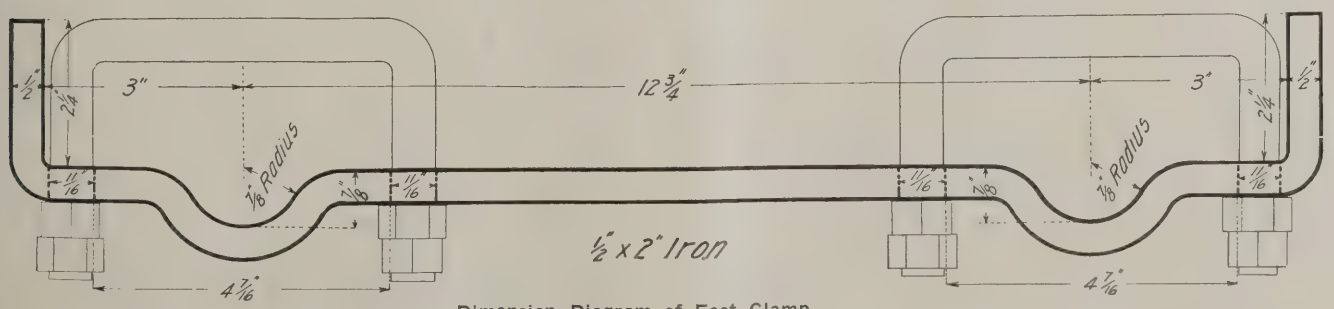


Dimension Diagram of "U" Bolt.

Grounding of Generator Leads.

I have had quite a good deal of trouble with the U. S. equipment, caused by the rear flexible either becoming grounded or opening. I find in all these instances that the generator is hung exceptionally close to the truck.

In motoring a machine in order to slacken the belt we push the machine back and sometimes the bolt holding the rear flexible lead smashes against the end sill of the truck. This also happens occasionally when the car is



Dimension Diagram of Foot Clamp.

on the road if the belt is too short, with the result that the wing nut breaks through the iron washer, demolishes the flexible insulating washers and grounds the flexible lead or allows it to drop out entirely.

In one case that has come to my notice, the bolt holding the flexible lead was driven right into the field coils and badly damaged them. This can be overcome, of course, by pulling the machine forward a considerable distance with the spacing irons but this would require a much longer belt. I find that by fastening a block on the end sill of the truck so that the machine will strike the block instead of allowing the bolt to strike the sill, this trouble can be overcome very satisfactorily.

George Greve.

Removing Armature Pulleys.

It is frequently necessary to remove a generator pulley and a pulley puller is not within reach in cases of this kind. The practice is to drive a cold chisel between the generator housing and the pulley. By doing this the flange on the pulley is frequently broken. Owing to the cold chisel having a sharp taper it throws the strain on the outer edge of the flange. By using two brake shoe keys (which can always be obtained in a coach yard), driving one in at the top and one in at the bottom and striking them alternate blows with a hammer the pulley can be quickly removed, and as the brake shoe keys have a very small taper they throw the strain on the heavy part of the pulley. A little judgment on the part of the person using them, and he will never break a flange. I have removed pulleys in this manner that I could not remove with a pulley puller. On Bliss type M-3 it will be necessary to lay an S wrench or something flat between the housing and the brake shoe key, owing to the large space between the housing and pulley.

W. B. H.

RESPONSE TO A TOUCHING APPEAL.

To the Editor:
I am inspired to relate
That your needs of dough is up to date.
When you have earned a measly pittance
You should not be ashamed to ask for remittance.
I am in hopes that all of those
Who are indebted to the Brother
May awake from their sweet repose,
And save him from disgrace,
Lest he be compelled to hide his face.
I hope this will stop your holler;
Please find enclosed a lonely dollar.
Yours truly,
O. F. Wiley.

Editor's Note—The above inspired was received in reply to a circular letter sent to delinquent subscribers. Did you get one? Hope not—it was a bad one, but we need the money.

BALL BEARINGS.

With the first application of ball bearings to car lighting service a little over two years ago, the majority of the car lighting men of the country were disposed to consider them as very much of an experiment. The past two years, however, has witnessed the equipment of over 500 axle generators with ball bearings, so it is evident that these bearings have now passed the experimental stage as applied to this service.

We have published from time to time various articles describing certain types of bearings, one of which is published in this issue; but we consider it of fully as great interest to give the operating experience of some of the roads using ball bearings for their axle generators.

We have written to various chief electricians requesting information on this subject and publish herewith a few replies received to date.

Mr. A. McGary, Chief Electrician of the New York Central Lines, advises that they have had four generators equipped with ball bearings in service for about 18 months, and have had a number equipped during the past six months. "Inspection of these bearings at different intervals has shown no development of trouble, either immediate or anticipated, and it would seem that the ball bearing is the proper bearing for these generators, and that long life and satisfactory service can be expected."

Mr. F. E. Hutchinson, Chief Electrician of the Rock Island Lines, advises that they have had ball bearings in service since July, 1912, and at the present time have 59 generators so equipped. "So far we have not experienced a single case of trouble on any of them. The men in the yard like these equipments and I frankly believe that the ball bearing is one of the biggest improvements that we have ever put on axle lighting generators.

"There is one precaution, however, that must be rigidly observed: The grease must be very carefully protected so that it will not get dirty and the bearings must be thoroughly cleaned to remove all grit and dirt before new grease is applied."

New instructions just issued by the Safety Car Heating & Lighting Co. for the care of ball bearings on their generators state that:

1. "When dynamos are put in service, grease pockets in caps Nos. 20074 and 20075 should be filled not more than two-thirds full of grease.

2. Ball bearings should not be allowed to run more than six months without examination, to see if they need grease. If more grease is needed, the bearings should be thoroughly washed out with kerosene oil and fresh grease applied as called for in first paragraph.

3. O. K. special non-fluid oil or No. 2-S-F Greoil should be used for greasing ball bearings.

4. Should experience demonstrate that the six months' period of inspection may be lengthened, information will be issued accordingly."

With a six months' period of inspection for bearings, it begins to look as if the axle lighting maintainer's job may be something easy before long, but even at that let's hope the good work may proceed and the six months' period of inspection be even lengthened as is suggested in these instructions.

NEW PRODUCT OF THE HOLOPHANE WORKS.

The Holophane Works of the General Electric Company, Cleveland, Ohio, have just placed on the market a new product, Sudan Glass Reflectors in Panelex Design. Sudan Glass is absolutely new in chemical composition, of very delicate amber tint, when lighted, and translucent. Its smooth surface is said to be ideal for lighting service, for though its finish is practically dust-resisting, there is no polish or glare. Specks, spots and other flaws have been entirely eliminated.

The Panelex Design of reflector is just as new as the Sudan Glass. This new style of reflector is without marked ribs or hollows that would catch and hold dust, and the lamp filament is hidden from the ordinary line of vision. Sudan Glass in the eminently practical Panelex Design, is said to demonstrate, to a new degree, large possibilities of light diffusion and re-direction without loss of artistic worth.

The reflectors are made in both the bowl and shallow types, and are particularly desirable for use in office buildings, retail stores, and some rooms of residences.

NEW BUSINESS DEVELOPMENT

The West is full of long distance transmission lines at voltages so high they almost topple, but it also has live wires of other kinds.

On February 1st the new business department of the Utah Light & Power Company organized a special excursion and tour of inspection from Salt Lake and Ogden to the Logan roundup. Gov. Spry and most of the members of the state legislature, as well as 225 members of the Utah Electric Club, were the guests of the expedition. Arrangements for it were made by Mr. C. Walter Jones, manager of the new business department; but what interests us most is the electric sign which is mounted directly on top of the last car. This sign is 60 ft. long by 26 in. high, and reads, "Utah Electric Club" on each side. The letters were made up of 15-watt tungsten lamps and current was taken direct from the 60-volt train line. A big searchlight was mounted on the rear platform of the last car and startled the natives as it was flashed in their houses a mile or two away; in all, the train was one grand blaze of electric lighted glory and Mr. H. R. Bucks, of the Oregon Short Line, was largely responsible for the success of this part of the expedition.

What is it? A Locomotive or an Aggregation of Fans at a Ball Game? Note Electric Sign on Last Car.

NEW METALLIC VAPOR LAMP, GIVING WHITE LIGHT.

Experiments reported by Dr. M. Wolfke, in the "Elektrotechnische Zeitschrift," seem to indicate the possibility of a new metallic vapor lamp which will give a clear white light containing practically all the colors of the spectrum.

The lamp as developed by Dr. Wolfke consists of the ordinary quartz tube in which is placed a cadmium-mercury amalgam instead of pure mercury as ordinarily used in metallic vapor lamps. When the lamp is not in use the cadmium amalgam solidifies and collects as a thin coating on the inside of the tube.

In all metallic vapor lamps it is the current passing through the metallic vapor, not any liquid or solid material which produces the light, so in order to start the lamp the cadmium amalgam in solid state must be volatilized. This is much more difficult than in the mercury lamp, but the author states that two methods are available. A small block of graphite attached by a flexible iron chain to the positive terminal which, on tilting the tube, can be made to come in contact with the cadmium amalgam cathode (negative terminal) of the lamp, the arc is started by tilting the graphite block back again, leaving the lamp to burn in its normal position. The second method consists in mounting a contact ring within the wall of the tube near the cadmium amalgam electrode, this contact ring being connected by a carbon filament of high resistance to the positive terminal of the lamp. When the lamp is extinguished the walls of the tube are covered with a thin conducting deposit of cadmium, and this is of sufficiently low resistance to allow a fairly strong current to flow between the contact ring and the cadmium electrode when the lamp is turned on.

The current upon passing through this very thin deposit of metal on the wall of the tube volatilizes it and starts the arc.

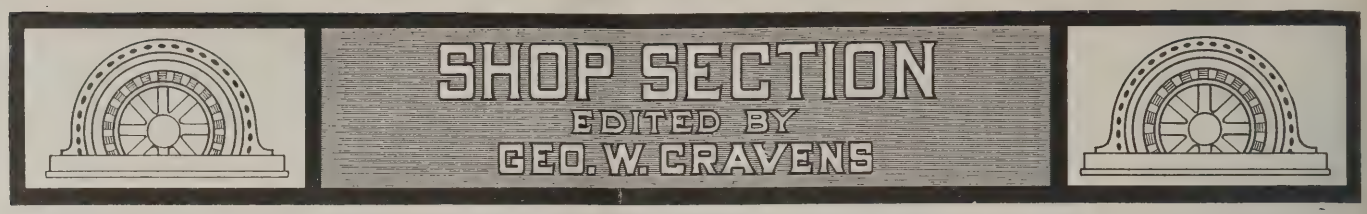
Pure vaporized metallic cadmium when subjected to electric current gives a light which is very rich in red rays so that illuminated objects have a dark red color. This difficulty is overcome, however, by the addition of from 3 to 10 per cent of mercury, depending upon the size of the lamp. Mercury being especially strong in the green section of the spectrum supplies this lack in the light from the pure cadmium with the result that the light produced by the cadmium amalgam vapor is an almost continuous spectrum, giving a very clear white light.

As to efficiency of operation, the author gives the following table which will be of interest.

Total watts.	Cadmium amalgam. C. P.	Cadmium amalgam. Watts per c. p.
150	150	1.00
220	310	0.71
300	590	0.51
380	960	0.40
540	2,370	0.23
620	3,800	0.16

REVERSING MOTORS FOR PLANERS, SLOTTERS, ETC.

The General Electric Company has just issued Bulletin No. A4081, devoted to the subject of Reversing Motors for Planers, Slotters, etc. The subject is treated in considerable detail, and the publication contains various curves which show the advantage of direct drive over belt drive, and, therefore, the advantage of reversing motors. The bulletin illustrates also various auxiliary appliances.



Motor Talk No. 6

ALTERNATING CURRENT MOTORS (Continued).

Last month we considered some of the elementary principles of alternating currents and motors, showing how single, two and three phase currents differ, how the rotating field in a motor is produced, etc. In the next few talks we will consider the various kinds of alternating current motors separately, so in this one we will give further consideration to a. c. motors in general.

When discussing motors it is necessary that certain terms be fully defined and peculiarities understood in order to prevent confusion, so let us see what the more common expressions and terms mean. The most important of these are Efficiency, Power Factor, Torque and Slip, so we will start with them. And, while we are at it, we will consider the effect and value of each of them in order to determine the differences between good and bad motors.

If a current of 1 ampere is flowing through a tiny motor under a pressure of 1 volt there will be 1 watt of power represented. To get 1 electrical horse power there must be 746 watts, either a large current at small voltage or a smaller current at a larger voltage. So, if you know the voltage of your circuit and the amount of current flowing, you can find the horse power represented by simply multiplying the volts by the amperes (to get the watts) and then dividing by 746 to find the electrical horse power.

The efficiency of any piece of machinery is the relation between the power required to run it and the power it gives back in the form of useful work, and is determined by dividing the output by the input. If a motor develops 10 h. p. ($10 \times 746 = 7460$ watts) and requires 10 k. w. (10,000 watts) to run it, we know the efficiency is 74.6 per cent because 746 divided by 10,000 equals .746, or 74.6%. The difference between 7,460 and 10,000 watts (2,540 watts) represents the internal losses, which are made up of stator and rotor resistance losses, core loss, friction and windage.

The efficiency of a motor at various loads is determined by the relative values of the various losses. A motor with high resistance losses will have higher efficiency at less than full load than when overloaded, and a motor with low resistance losses will show a higher efficiency on overloads than when running only partly loaded.

Alternating current circuits present several peculiarities not found in direct current circuits, one of the most important of which is the tendency of the current to lead or lag behind the voltage. Induction motors tend to cause a lagging current to flow in the line and synchronous motors can be made to cause a leading current to flow, and both of these conditions will be explained when describing these motors. When measuring the power in a circuit with a wattmeter we get the *apparent* power only, because such meters are affected by the amount of lag or lead of the current. So, to get a record of the *actual* power we must use a voltmeter and an ammeter and multiply the readings to get the true volt-amperes or watts represented.

A kilo-watt equals 1000 watts and a kilo-volt-ampere equals 1000 volt-amperes, so, to get the power factor of a motor we must divide the apparent power by the actual power put into it. If we have a motor taking 10 k. w. to run it on a 500 volt circuit, and our ammeter shows the current flowing to be 25 amperes, the k. w. will be 10 and the k. v. a. will be 12.5, so, the power factor will be .8 or 80%, because 10 divided by 12.5 equals that. The power factor of a motor is affected by the reactance drop and the magnetizing current of the motor.

A motor with a relatively large magnetizing current and a low reactance will in general have a low power factor at low loads and a rapidly increasing power factor at higher loads, while a motor with a relatively low magnetizing current and a high reactance will have a high power factor at low loads but only a slightly greater power factor at overloads. With the line voltage constant the magnetizing current remains practically constant, whereas the reactance drop varies with the current.

Torque is the mechanical rotative or turning force which acts on the armature of a motor and causes it to turn. Torque is usually measured as being equal to the pounds pull at the end of an arm or radius of 1 foot from the center of the armature shaft, and is exerted by the electro-magnetic action or pull at the windings of the armature. It is measured in pound-feet and *not* in foot-pounds, as is so often wrongly stated, because foot-pounds is the measure of energy and not of mechanical pull.

The starting torque of an induction motor may be two or three times that of its running torque, but the current at starting will also be greater. The torque at starting is effected directly by the rotor resistance and by the square of the line voltage, and inversely by the square of the impedance. (Impedance is the virtual resistance of an a. c. circuit and corresponds to the straight ohmic resistance of a d. c. circuit. It is also measured in ohms.)

The running torque is directly dependent on the rotor resistance, the slip and the square of the voltage, whereas the maximum torque is independent of the rotor resistance. The current taken by an a. c. motor in starting is equal to the impressed voltage divided by the impedance, whereas with d. c. motors the current equals the voltage divided by the resistance.

Slip is the proportional difference between the speed of rotation of the magnetic field and the speed of the rotor. (In Motor Talk No. 5 we explained how the rotating magnetic field was derived.) The amount of the slip or drop in speed is dependent on the resistance of the rotor, and speed variation of induction motors is sometimes obtained by providing suitable means for regulating the resistance of the rotors of such motors.

The slip of an induction motor, over the usual ranges of operation, varies directly with the load and the resistance of the rotor and inversely as the square of the voltage. In well designed motors the slip should be between 2% and 5% of the synchronous speed, although in very small motors it will be more. In order to develop torque it is necessary that the rotor

should slip, as will be seen by the following explanation.

When current is sent through the field windings of an induction motor a varying magnetic flux is set up which crosses the armature coils and generates or induces an E. M. F. in them. Since these coils form closed circuits this E. M. F. causes currents to flow in them, and this causes the armature to rotate by the reaction of these currents on the field. If the armature is held so it cannot turn, the coils will have heavy currents induced in them the same as in the secondary of a transformer.

But, as the armature comes up to speed the relative motion between the rotating magnetic field and the armature becomes less, so the induced E. M. F. and current becomes less because the armature coils cut fewer magnetic lines of force than before. If the armature revolved exactly in synchronism with the magnetic field there would be no cutting of lines and no induced current, so there would be no torque exerted. Hence, in order to induce currents and produce torque, there must be a difference in speed or slip between the armature and rotating field, and the greater the torque required in a given motor the greater must be the slip. When running light the speed is almost synchronous.

From time to time during this series of Motor Talks we will give other definitions as needed, and we hope our readers will freely ask any questions which occur to them. Our Question Box is for answering them and is open to all.

QUESTION BOX.

Editor Railway Electrical Engineer.

Dear Sir: Will you please tell me if the weather has any effect on electric motors? In our shop we have a lot of induction motors, driving machine tools, and when it was so cold a little while ago the motors would run slow. Sometimes they will run too fast, but generally the trouble was the other way, and they did not seem to have as much power as they usually do, either. We examined everything carefully, but could find nothing wrong. Our electrician looks after the power house and said the generator is all right, and that the only thing which bothered him was the gas engine which drives the generator. We use 220 volts in our shop, and the frequency is 60 cycles.

R. D. K.

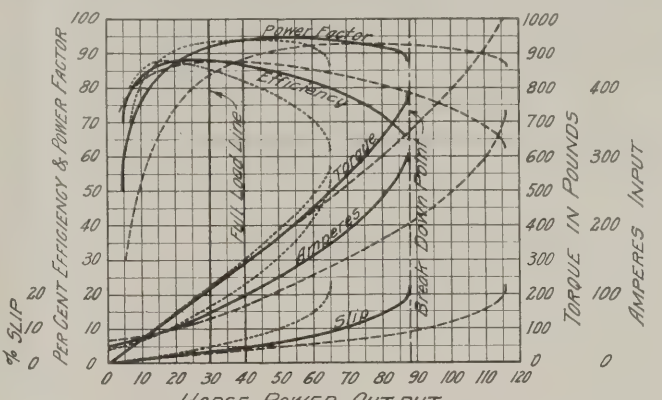
Answer.

Your trouble is apparently not due to the effect of the weather on the motors, but rather to its effect on the gas supply. Variations in temperature only effect motors by varying the radiation of heat, and cold weather helps unless it is cold enough to harden the oil in the bearings. But gas is effected because moisture condenses in the mains and the pressure is also reduced, so you will probably find that the trouble your man had with his gas engine is the real fault.

As to the motors, the speed variation there was undoubtedly due to the engine trouble. For, as the engine speed changed, the generator speed would also change and that would effect both the voltage and the frequency of your system. If you will examine the accompanying curve sheet, showing the effect of voltage variations on an induction motor, you will note that the torque, current, efficiency and power factor all change with changes of voltage.

The solid lines indicate the characteristics when operating at normal voltage, the dotted lines show them at 15 per cent below normal voltage and the dash lines show characteristics when the voltage is 15 per cent high. Other variations in the potential impressed on the motors will cause proportional changes. The torque or pull of an induction motor varies as the square of the voltage, so a reduction from 220 volts to 110 volts will reduce the torque to one-quarter of normal, and an increase to 440 volts would make the torque four times normal.

When the voltage is too high, the motor will take less current (the watts being practically constant),



Characteristic Curves of 30 h. p. Motor.

but the magnetizing current will be increased, and the power factor will be lowered and the efficiency raised slightly at full load. A reduction of voltage has the opposite effects, but the variation will be much greater and more noticeable. The heating is also increased at reduced voltage, and vice versa. The starting current drawn from the line for a given torque will vary inversely as the line voltage for all types of induction motors. The slip of induction motors for given torques also varies as the squares of the voltage, unless the variation is large.

G. W. Cravens.

TRIGGER-LOCK REVERSIBLE CONTROLLER FINGER.

One of the most serious items in the maintenance of electric crane controllers is that of the controller fingers. The new reversible trigger-lock finger is a radical improvement over the ordinary fingers in general use and will be of interest to railroad men.

There is no wear on the phosphor-bronze finger itself, there being a renewal tip slipped on over the finger and snapped into position as shown. This can be removed by simply gripping the return spring loop of the finger with a pair of pliers, and the tip can then either be reversed or replaced by a new one in a moment's time.

A standard size fold and recess has been adopted so that all tips will fit any size of finger. This greatly simplifies the renewal of tips, for when the finger is once fitted, all tips are standardized and interchangeable. It is not necessary to carry a stock of different tips for different size of controllers.

This device is being marketed in this country by Richard Russell, 74 Bay street, Toronto, Canada.

F. F. FOWLE RESUMES ACTIVE ENGINEERING WORK.

Frank F. Fowle announces that he has severed his connection with the McGraw Publishing Company as one of the editors of Electrical World, and will resume his electrical engineering practice with offices at 68 Maiden Lane, Suite 1702, New York City.

Motor Drive for Railroad Repair Shops

The advantages of electric motor drive applied to machines and tools in shop operation have been firmly established in practice. It is rare indeed that railroad repair shops are designed nowadays without providing for electrical operation of the machinery, and the tendency to modernize older, existing shops by making the necessary changes to arrange for driving throughout by motors is ever increasing. Convenience, simplicity, economy of operation, increased output, better light, safety are some of the characteristic benefits resulting from electric drive that have induced its adoption wherever possible by the heads of mechanical departments.

It permits of centralization of power and a flexibility of distribution and control that cannot be secured easily any other way. Driving machines either individually or collectively are the two methods in general use. The usual practice has been to drive larger machines, such as big lathes, planers and boring mills, by independent motors and to operate smaller tools in groups from line shafting, belting each section to a motor. The latter method was often adopted when individual drive throughout would have been better, necessitated by the fact that earlier types of motors were large and unwieldy and not suitable for mounting on headstocks of lathes or for direct connection to other machines. The greatly improved design of modern motors built specially for driving shop machinery embodies compactness, a wide range of sizes and requisite speed variations when desirable. Present motors, equipped with commutating poles in general and using field weakening rheostats, make any speed variation up to and including four to one wholly practicable. Constant speed motors, however, fulfill the requirements largely and have been equally well developed for industrial service.

Probably seventy-five per cent. of the electric power used for shop operation is required for constant speed machines and lights. The simplest form of alternating current motors, namely, the induction type with squirrel cage winding, is essentially a constant speed machine, entailing little care and minimum maintenance charges. Motors of this type are well adapted for the operation of machine tools for which constant speed drive suffices. Where adjustable speed machinery has to be considered, the direct current motor with field weakening control probably offers the readiest solution for power application. Alternating current motors. however, have been applied very successfully for variable speed work to cranes, transfer tables, turntables, hoists, etc.

In the railway shop power house, the most satisfactory arrangement for generating current consists of alternating current generators coupled either to turbines or reciprocating engines. Whatever direct current may be needed can be supplied from motor-generator sets composed of direct current generators driven by synchronous motors.

The line of both direct and alternating current motors manufactured by the General Electric Company provides for every application of electric power to machines and tools in railroad shops. For direct current constant speed operation, the type CVC motors ranging in standard sizes up to 20-hp., moderate speed, and the DLC motors built in sizes of 10-hp., slow speed, and above are recommended. The direct current motors types RL ½ to 1 hp. and RLC 2-hp. and above are designed for adjustable speed service. All of these motors are of rugged and symmetrical construction with low centers of gravity, and are adapted especially for the severest duty in driving machine tools. They are of the commutating pole design, which affords superior overload and operative characteristics. Freedom from sparking is practically assured, and in connection with the adjustable speed motors a wide range of speeds is obtained through field control. Motors of this type render the highest all day service efficiency, especially where the fluctuation in voltage or the power demands are heavy.

For constant speed service the form K line of alternating current motors for polyphase circuits is especially applicable. Motors of this type are built with riveted frames in ¼ to 10-hp. sizes and with skeleton frames in sizes 10-hp. and above. They have extreme simplicity of construction and great durability, owing to the squirrel cage type of short circuited windings employed. For starting, a compensator is connected in circuit with motors of 7½-hp. and above. The type RI alternating current motors, having standard sizes from 1 to 15-hp., are designed for constant speed service on single phase circuits. Type RI motors are also adaptable for variable speed. By means of a speed controller, CR-172, a speed range of fifty per cent. reduction from synchronous speed is obtained.

For variable speed the type M polyphase alternating current motors are built with riveted frames in sizes up to 10-hp. and with skeleton frames for sizes of 10-hp: and above. These motors are of the collector ring type. A variation in speed within certain limits is secured by inserting resistance in series with the rotor, provided the torque against which the motor works is fairly constant. With some machine tools, such as boring mills, lathes, etc., the torque varies widely, and consequently the Type M or type RI variable speed motors are not ordinarily suitable for use under such conditions. For service where a number of definite speeds will answer, the Type KT polyphase multispeed induction motor has been developed on both constant torque and constant horsepower machines. This type of motor permits two fixed speeds, such as 600 and 1200, or 900 and 1800 r. p. m.; or four speeds, viz., 600, 900, 1200 and 1800 r. p. m. As the multispeed motor operates as fixed speed, regardless of load, this type is therefore suitable for use with lathes, boring mills and similar apparatus. All motors may be arranged for direct connection or for chain or belt drive to machines.

For the control of motors when operating machinery, where frequent stopping and starting is essential, drum type controllers have been found to give much better satisfaction than other types. The General Electric Company offers a complete line of these controllers for both constant and adjustable speed motors when applied to individual drive. All drum controllers for machine tools are arranged for reverse operation. When non-reversing controllers are desired, a stop is screwed into the controller cap plate, against which the handle strikes at off position. They may be arranged to operate through gears or sprockets.

For direct current, Type R drum controllers are designed in a number of capacities for both constant and adjustable speed motors; while for alternating current variable speed motors of the slip ring or multispeed type, drum controllers designated Type T are offered in suitable sizes.

When overload and no-voltage protection are required in addition with direct current motors. Type

CR-247 panel should also be used. This panel consists of a double-pole circuit breaker for protection against overload and a single-pole contactor for no-voltage protection.

Railway motors are generally provided with a very large number of turns in the field coils in order to magnetize the fields with a comparatively small current flowing. This gives a field of nearly constant strength at all loads and results in better speed regulation, as well as reducing the sparking at moderate loads. The mechanical design of railway motors is very different from motors for stationary uses, but in general the relation of the parts is the same.

Two general types of starting devices or controllers are used for series motors, resistances with dial switches or with drum controllers. The former consists of a series of contacts arranged in the form of a part of a circle, with an arm pivoted in the center and making contract with the buttons or segments as it is moved around to vary the resistance. The drum controller consists of a cylindrical body carrying several circular contact rings and mounted in a box, with fingers arranged to touch the rings and cut in or out the resistance as the drum is revolved. In both cases the resistance box is connected to the switching device by several wires.

Series motors are nearly always made to connect direct with the machine to be driven, either through gearing or couplings, because the use of belts is liable to lead to trouble if they slip off the pulleys. This has resulted in having many of the motors made with a shaft mounted on the back of the frame and geared to the armature shaft for the first reduction of speed. Motors for cranes, turntables, railway cars, etc., are made this way, with chain drives for some special applications.

General Electric Ozonators

The ozonator is an apparatus for generating ozone in moderate quantities by means of a high pressure electrical discharge through air. It represents the concrete result of investigations and experiments extending over a period of years, and its purpose is to deodorize and sterilize vitiated or indoor air. Ozone diffused throughout a room quickly purifies the atmosphere. Ozonators consume a very small amount of current and the cost of operation is trifling. The value of these machines for promoting health is readily apparent, and they are rapidly coming into general use in places of public assemblage, such as railway waiting rooms.

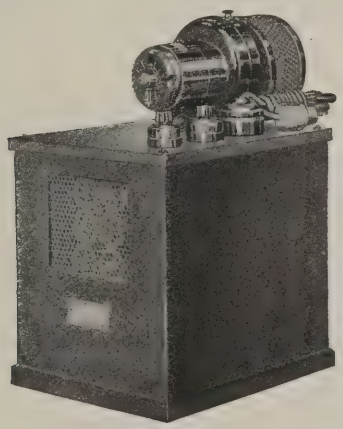


Fig. 1. View of Ozonator.

Although ozone, its properties and useful application have been known and studied by scientific authorities for many years, probably a large percentage of the public is not acquainted with its valuable characteristics and practical use. In 1785 von Marum observed that oxygen or air through which an electric discharge had taken place was possessed of a peculiar odor. He referred to this as the "smell of electricity." The same "smell" is distinctly noticeable if one happens to be in the vicinity of a bolt of lightning during a thunder storm. It is caused by some of the oxygen in the air being changed into ozone, which produces the particularly fresh and wholesome smell of the atmosphere after an electrical storm.

Ozone is a colorless gas, over a wide range of pressure and temperature, with an odor in mild concentrations resembling somewhat that of chlorine and in strong concentrations resembling that of phosphorus. It is an allotropic modification of oxygen of the formula O^3, and is an endothermic compound, that is, one formed by the absorption of energy. In the presence of oxidizable, or, in general, organic substances, this energy is dissipated, one atom forming a stable compound with the substance and the remaining two existing as ordinary oxygen. The action of ozone in the atmosphere, through chemical affinity, oxidizes or burns up floating bacteria and microscopic impurities, in which the percentage of carbon is high. It has a germicidal effect in respirable quantities with no deleterious action on higher forms of animal life. It is Nature's own method of purifying air.

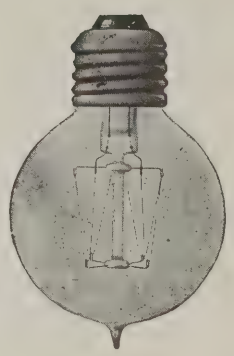
The General Electric Company manufactures four types of ozonators, the Utility, Household, Universal and Industrial. All of these contain a step-up transformer, an ozonizer and, in some cases, a blower. The transformer is located in the lower part of the case and changes the supply voltage in the alternating current machine to a value sufficiently high to produce ozone when applied to the ozone generating units. The correct voltage has been very definitely determined and is established at a value that will not give nitrous oxide within limits which can be detected by the recognized methods of measurement. Above the transformer is the ozonizer proper, consisting of a bank of ozone generating units. Each unit consists of a cylindrical glass tube, copper plated on a portion of its outer surface, and within which is an electrode. The latter is built up of shallow perforated enameled cups mounted on a spindle concentric with the tube. The cups are of such a diameter as to allow a small but definite air gap between them and the bore of the glass tube.

One high voltage lead from the transformer is connected to the outer coating of the glass tubes which are in multiple, and the other to the aluminum electrodes which are also in multiple. The charge on the outer coatings of the glass is induced on the inside of the tubes and a violet electrical discharge takes place between the inside of the tubes and the aluminum electrodes. This discharge through the air in the small air gap changes some of the oxygen into ozone.

For use in the home, factory, railway waiting room, or public buildings of any sort, the ozonator is rapidly win-

The Five Essentials

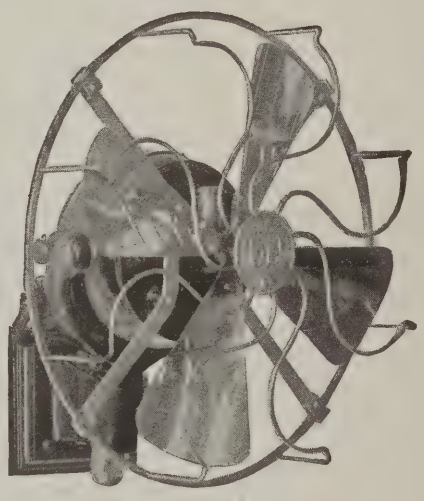
Columbia Mazda Lamps



Drawn Wire Filaments

The mechanical strength of the new Columbia Mazda Lamp has added greatly to its life. In addition it has increased electrical efficiency. We carry an immense stock of low voltage lamps for train lighting service as well as the standard sizes and styles of lamps for ordinary voltages.

The Standard for Train Lighting



Diehl Car Fans

FOR

Railway Car Service

They are the best. When the manufacturers could no longer improve the motor they improved the base. These bases are of artistic design and may be permanently mounted in the cars. The Fan is easily and quickly removed without disturbing its base. No marring of woodwork—no loss of time.

Ask for Additional Information

Demand on all your orders QUALITY
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or West. Prompt shipments are our
ing catalogue, it will go to you for the

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320-326 South Fifth Ave. *The House*

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OKONITE
TRADE MARK.

Standard of All Rubber Insulations

Okonite insulation with its toughness, elasticity and high electrical resistance is always placed concentrically around the conductor. The result is a product absolutely dependable.

Wire installed in railway cars should be the best. *Okonite* is made in one grade only—THE BEST.

D. & W. Fuses

The Standard by Which All Enclosed Fuses Are Judged

Construction of link used in fuse in operating under severe conditions.

D. & W. Fuses are scientifically designed with maximum service and a resultant minimum volume of metal for a given current value. This enables fuses of reasonable dimensions to meet abnormal conditions of overload. The fibre tubes are exceptionally strong. They are manufactured with steel reinforcing rings when necessary.

Specify D. & W. Fuses and secure the protection you need.

and SERVICE—then write us. We are largest stock of electrical supplies East specialty. If you have *not* our big instruct- asking. Write for it on your letterhead.

rir Company

of Service CHICAGO, ILL.

ning public approval. It assures a healthier atmosphere and is conducive to more pleasant surroundings. Through providing waiting rooms with ozonators, railway companies will discover a valuable auxiliary for ingratiating themselves still further into public favor.

THE SHURLOCK LAMP SOCKET.

There is little doubt but that the item of stolen lamps and lamps broken due to falling from their socket comprises a large part of lamp maintenance expense for railway cars, stations, shops, office buildings, roundhouses, etc. The Shurlock adjustment as developed by the Pass & Seymour Co. and illustrated herewith, provides a means whereby this item of maintenance expense can be entirely eliminated. The Shurlock is an integral part of P. & S. Shurlock sockets and receptacles, whereby the theft or unauthorized removal of the incandescent lamp is prevented.

It is constructed, as shown in the split view, and has a small set screw passing through the shell of the socket

Fig. 2. Shurlock Lamp Socket Showing Internal Construction.

and engaging the base of the lamp. This set screw is thoroughly insulated from the shell by means of the very best white horn fibre. The head of this set screw is of a peculiar triangular shape, and it is not possible to unlock the screw with any of the old fashioned watch keys, or any other devices.

The largest electric lighting company in Chicago installed several thousands of these on their rental cluster service. The installation cost them $8,000. The saving in lamp renewals was $42,000 per annum.

They told an interesting story of one of their employes who left his key at home. He had occasion to attempt to change a lamp. It was after hours and the keys were all locked up. They had a big supply of tweezers, small nose pliers and all that sort of thing. This man spent 2½ hours, using these miscellaneous odd tools trying to remove the lamp, but finally gave it up. He released it the next day within a quarter of a minute, because he had the proper master key.

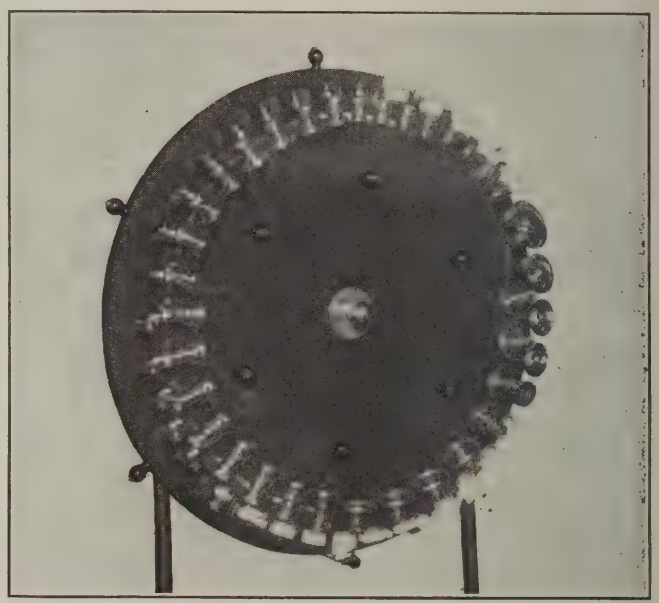
EDISON STORAGE BATTERY COMPANY BUILDS NEW FACTORY.

The Edison Storage Battery Co., is building a new six story addition to their present plant which, when completed about January 1st, 1913, will provide a total floor space of over 22 acres which is devoted exclusively to the manufacture of Edison Storage Batteries.

NOVEL DISPLAY PANEL BOARD.

The accompanying illustration shows a novel panel board design which formed a part of the exhibit of the Bryant Electric Company at the recent sales convention of the Western Electric Company in Chicago.

The board consists essentially of two large concentric discs, the larger one being rigidly fastened to the supporting frame, while the small one is free to revolve. Mounted on the periphery of the stationary disc were 35 brass socket caps and bases, representing



Revolving Combination Display Panel Board.

all the different types of the "New Wrinkle" line. On the outer edge of the smaller movable circle were also mounted 35 sockets, all of which are interchangeable and go with any of the 35 caps or bases. By revolving the wheel any combination of any certain socket with a certain base or cap can be shown. In all, this makes 1225 combinations possible.

ELECTRICAL ARITHMETIC.

A new catalogue just published by the Electric Controller and Manufacturing Company, of Cleveland, Ohio, under this title, contains about a dozen practical motor problems each of which shows some specific application of automatic starters and controllers. The booklet contains many practical stunts which will be of interest and value to railway shop electricians.

NEW QUARTERS FOR THOMPSON ELECTRIC.

The Thompson Electric Company announces that on account of having outgrown its former quarters it has moved its office and assembly shop to 102 St. Clair Ave. N. W., Cleveland, Ohio. The Thompson Electric Company manufactures an automatic cutout hanger for arc lamps and tungsten units which lowers the lamp right down to the ground without jarring or jerking, cutting it entirely out of circuit.

RAILWAY ELECTRICAL ENGINEER

Official Journal
of the Association of Railway Electrical Engineers.

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OUR OBJECT.

The object of this publication is to provide a medium for the free interchange of ideas and experience among those identified with the operation of electrical apparatus as applied to railway practice.

In this mutual exchange of ideas among the men prominent in the field there will result a better understanding and solution of the problems before us and a wonderful inspiration for all to greater achievements.

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Electrical School for P. R. R. Men.

The Pennsylvania Railroad has always been noted for its progressive and far-sighted policies, not only in preserving its natural resources in reforesting large districts and in the active development of new and more efficient railroad equipment, but in the education of its men as well.

Consistent with its liberal policy, the P. R. R. has just established a School of Electricity for its employees as outlined in another part of this issue, so that when the day of the more extensive electrification of main line divisions arrives, the present force of Pennsylvania men will be well trained in electrical matters and fully competent to meet the entirely new conditions of operation and maintenance imposed by electrification.

The P. R. R. has already made plans for the electrification of its line from New York to Washington and the establishment of this school is without doubt very significant of the near approach of extensive electrification of trunk line divisions. The employees apparently fully appreciate the situation and realize the need of a knowledge of electricity, for within a month after the establishment of this school 10,000 of them were enrolled.

Aside from the matter of electrification, however, wonderful advance of electricity in every branch of railroad operation has made it almost imperative that a railroad man be posted at least in the fundamentals of electricity. Whether considered as an advance training to meet the great electrification projects of the near future, or simply as a general training in the operation of the vast amount of electrical equipment now in service, the establishment of this school of electricity is a sign of the times and indicates an awakening appreciation on the part of the higher railroad officials of the importance of electrical equipment in all branches of railroad operation.

Combination Fan and Lighting Fixture.

The gyrofan unit has been installed to a considerable extent in dining cars but one objection to these units has been the fact that twice the number of fixtures were required and the upper deck of the car became congested with electrical equipment, so that the beauty of the car ceiling panels was largely destroyed. With the new combination gyrofan lighting fixture, as described in this issue, this difficulty is entirely overcome. Since the fans are mounted above the lighting unit they are free to revolve, yet do not cause any revolving or flickering shadows.

Although this particular installation may not have very great merit from an artistic point of view, the idea is good and when a lighting fixture of the proper design has been installed, the fixture should become one of beauty as well as one of convenience and economy.

Gravity Readings in the Winter Time.

It has been general practice to take specific gravity readings of storage batteries in car lighting service upon reaching the terminal and this specific gravity indication is then used as a basis for determining whether or not the battery is sufficiently charged. The general practice in car lighting service is to keep the electrolyte at a gravity of about 1.220 when the battery is in a fully charged condition and at normal temperature. In actual practice, however, the storage battery is rarely found to be at the normal temperature of 70 degrees F. In the winter time it may run down as low as 20 or even 30 degrees below zero in certain cases, and in the summer time it may run up as high as 110 degrees on certain lines operating in the south and across the arid plains of the west.

Under such conditions if the storage battery electrolyte is maintained at 1.220 specific gravity, unsatisfactory operation is almost sure to result. As the electrolyte warms up the gravity goes down, and as it is cooled to low temperature, such as is experienced in winter time, the gravity goes up very materially. In the summer time when operating at 95 degrees in the shade this normal gravity, which at 70 degrees F. is 1.220 then becomes 1.210, at 40° F. it is 1.230, at 10° above it is 1.240, and at 20° below this normal gravity is 1.250. A reading of even 1.230 in severe winter

months may indicate that the battery is not fully charged, while on the other hand a fully charged battery may never show a gravity above 1.210. This clearly demonstrates the importance of considering temperature when taking gravity readings at the end of the run to determine battery condition.

If the electrician adds acid in the warm months or adds water in the winter time to bring the gravity back to 1.220, it will in the first case damage the battery by sulphating the plates, due to the combined influence of high temperature and strong acid, possibly 10 points stronger than it should be; and in the winter time when the battery capacity is somewhat reduced the dilution of the electrolyte will still further reduce its capacity.

Temperature is an important item in all gravity readings and the men on the job should be fully informed on this point.

Philadelphia Electrification of P. R. R.

Although there is at the present time no official information available regarding the details of the electrification of Pennsylvania Lines between Paoli and Philadelphia, it is rumored that alternating current will be used and that energy for operating the electrified zone will be purchased locally for the next few years at least. It is stated that this improvement will involve an expenditure of approximately $4,000,000.00 and it will be completed some time in 1914.

With the electrification of the Baltimore terminal and tunnel of the Pennsylvania, which will undoubtedly follow shortly, and with the electrification of the terminal at Washington, there will be established three very important links in the chain of the long prophesied New York to Washington electrification.

Notes on Railway Electrification Progress.

The activity in railway electrification never was more marked and never had a more hopeful prospect than at the present time. In the United States, with the opening of the New Haven section of the N. Y., N. H. & H. R. R. this month, the electrified portion of that system will extend to 35 miles. A special railroad conference has been appointed which is composed of twelve citizens, two appointed by each of the governors of the six New England states. This body will consider the best methods of developing and operating the New England railroad system, including the project of electrifying the terminals and providing adequate electric traction in both city and suburban districts.

England. The electrified section of the Lancashire & Yorkshire railway has just been extended from Liverpool to Ormskirk. Electrically operated trains were put in service on April 1st.

Italy. It has been decided to electrify the branch lines of the Italian State Railways from Giovi to Sampierdarena and Roneo. This work will cost approximately $10,000,000.00 and the decision to electrify this section is the direct result of the success of electric traction on the Giovi main line.

Germany. The contract for the construction of a new mountain railway in the Riesemgeburge, seventeen miles in length, has just been awarded the Allgemeine Electricitats Gesellschaft. The system of working with single-phase current at 15,000 volts and 16 2/3 cycles on the Dessau-Bitterfeld line is now adopted for the Magdeburg, Leipzig and Halle section.

Panama. The Panama Railroad is to be electrically operated. The transmission voltage will be 44,000, stepped down at various distribution centers for running the trains, lighting the canal, and supplying the power required for operating the various machine shops, the gates, the towing locomotives, and other appliances at the dams and locks.

Our New Headquarters.

Advertising is one of the greatest known forces in all commerce, yet, strange as it may seem, the newly completed advertising building in Chicago is the only building of its kind in the world which is devoted exclusively to the interests of advertising. This building has just been completed and on May 1st the *Railway Electrical Engineer* moved into commodious quarters on the eighth floor. This building is centrally located at 123 W. Madison St., half block East of the LaSalle Hotel, and we hope that our many friends will take opportunity of calling upon us in our new home.

ASSOCIATION NEWS.

June Convention.

The semi-annual convention of the Association of Railway Electrical Engineers, which is to be held June 15th, will undoubtedly attract a large number of electrical men of the railroads from all over the country, for in addition to the committee reports and interesting papers presented at this meeting, there is the additional attraction of being able to attend the M. M. and M. C. B. conventions as well as the opportunity of seeing the great exhibit of railway appliances. A. R. E. E. headquarters are to be at the Hotel Dennis and our Secretary specifically requests that all members attending the convention register at this hotel as a member of A. R. E. E.

A special train known as "The Master Mechanics Special" will leave Chicago over the Pennsylvania at 3 p. m. Monday, June 9th, arriving at Atlantic City about 2 p. m. the following day without change. This train is composed of all steel cars, electrically lighted and is made up of sleeping, dining, library, observation and smoking cars. Tickets will be on sale June 1st with 30 days return limit. Fare for the round trip from Chicago will be $29.25.

The Question Box.

The question box of the Association can be made a most valuable feature not only to the man who asks the question but to all of our readers, and particularly to the man who answers it, provided a sufficient number make use of it. There is nothing that will so thoroughly inform a man on any subject as to go to the trouble of explaining it to somebody else.

The question box department of the American Electric Railway Association covers about 15 pages in their monthly magazine and nearly two dozen new questions come up every month. Although the electrical departments of the steam railroads are at the present time much smaller in numbers of men employed than the street railway field, the difficulties of operation and the problems involved in the design and installation of electrical equipment are equally, if not more important, than those of the latter field. It is certainly to be hoped that A. R. E. E. members will give this subject the proper attention so that the greatest possible benefit to all may result.

Proceedings of the Association.

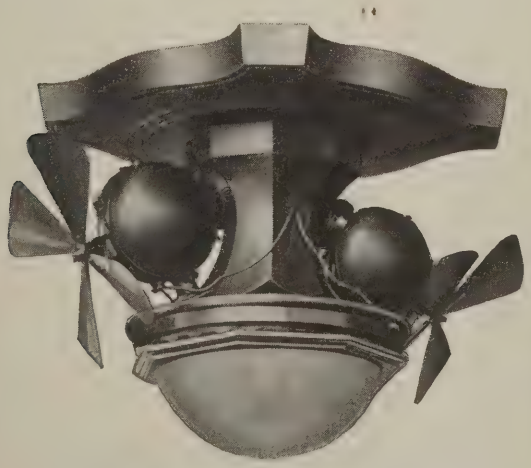
Secretary Andreucetti advises that volume No. 5 of the Proceedings of the Association for 1912 are being sent out this week. There has been considerable delay in publishing these proceedings, largely occasioned by the delay in members submitted their corrected remarks.

Combination Fan and Lighting Unit on the Lake Shore

One of the most distinct improvements in car lighting fixtures of recent date is that of a combination gyrofan lighting unit as shown in the two accompanying illustrations below. The advantages of such a unit are at once evident, as it entirely relieves the congested appearance of the upper deck when gyrofans are suspended between each of the center deck lighting units.

This equipment as shown was installed on one of the Lake Shore diners and was originally designed by the Lake Shore engineers, with the assistance of the engineers of the Adams Bagnall Electric Company.

The Gyrofan Lighting Fixture in a Lake Shore Diner.



Showing Detail of the Fixture Construction.

The gyrofan is placed directly over the lighting unit and revolves about the center stem of the fixture as an axis. Fifty-watt tungsten lamps are installed in each of the center deck and 25-watt lamps in each of the quarter deck units, which are mounted directly over each table. The enclosing bowl of the center deck unit of this particular installation is a large Holophane bowl. By some, this may be criticised as being rather lacking in ornamental lines, but the artistic effect can undoubtedly be greatly improved by installing some of the later types of box fixture units, such as the hexagonal unit with prismatic bottom plate as described in our issue of May, 1912. In all justice to the designers of this particular equipment, however, it must be remembered that this is the first car to be equipped with this combination gyrofan lighting unit and such material as was at the time available was used in its construction.

This makes a very compact unit, being about 16 in. over all, so that there is plenty of head room in the car. With the addition of a more decorative lighting fixture, this unit can be made a very attractive and

pleasing one from the artistic point of view, while both the saving in space and fixture expense effected by this unit should be very material.

One of the chief points of advantage aside from the compactness of this double unit, is the fact that the fans are placed above the lighting fixture so that there is no flickering shadows caused by the fans either at rest or in motion.

Most Powerful Electric Locomotives in the World

New High Speed Type. Represent Signal Advancement in Electric Locomotive Design. Ten Will be Placed in Service in New York

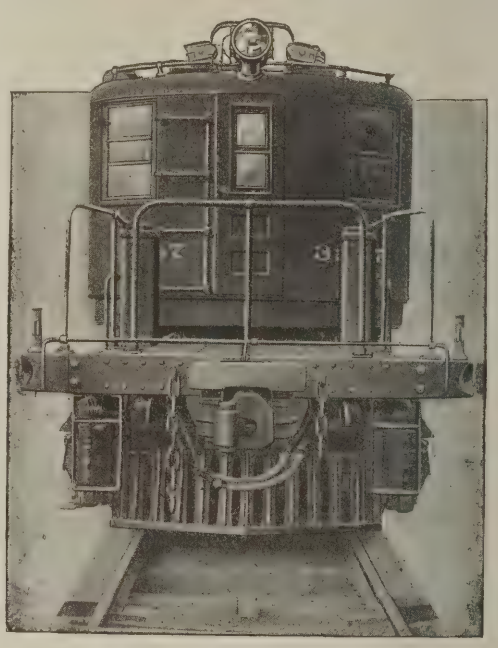
Known as the "New high speed marvel," ten passenger electric locomotives of the most powerful type ever built are to be placed in commission by the New York Central & Hudson River R. R. Co., out of New York City. A very exhaustive series of tests and trial runs of an experimental locomotive of this type was recently made on the Harlem Division. This locomotive was immediately put in service on the electrified section of the New York Terminal and a contract was awarded the General Electric Company for nine additional locomotives of the same design, which are now under construction.

The electric locomotives in service in the Terminal previous to the introduction of the new engine weigh approximately 115 tons. While the new locomotives are considerably lighter, weighing 100 tons, they are much more powerful, are provided with ample forced air ventilation and designed with a view to continuous high speed service. All the 100-ton weight is carried on motor-driven axles, while the former locomotives have but 70 tons weight on the driving wheels.

The new electric engines will exert sufficient tractive effort to haul a train weighing 1,000 tons at 60 miles per hour. In regular service they have a capacity for developing 1,400 horsepower continuously and can develop as high as 5,000 horsepower for short periods. Compared with existing types of electric locomotives, this machine has greater capacity and higher efficiency than any other high speed electric locomotive ever constructed. Withal, its total weight, weight on the drivers and "dead" weight is less than that of its nearest competitor.

Briefly, the history of the development of the New York Central latest type of 600 volt, direct current, passenger, high speed electric locomotive recounts a notable achievement in designing skill. The original New York Central electric locomotives had guiding wheels in the form of a pony truck with 28,000 pounds on the axle. There were four driving wheels, each carrying the armature of a direct current, bipolar, gearless motor. To improve the riding qualities of this pioneer express electric locomotive, a guiding bogie truck having two axles was substituted for the pony truck. A further development in a subsequent type was to increase the distance between the guiding trucks and the rigid wheel base. The riding qualities were improved, but at a loss in the mechanical efficiency of the locomotive; for about 40 tons of surplus weight had been added and were being carried by the bogie trucks for the sole purpose of guiding the locomotive. The addition of motors to the bogie trucks and the elimination of this ineffective weight was the next step, so that every pound of the locomotive weight would be instrumental in producing adhesion and tractive effort. A still greater separation of the fixed wheel base and the guiding trucks lengthened the machine so as to necessitate constructing the running gear in two halves with a spring-connected articulated joint between the frames. Thus has been evolved the "New high speed marvel."

At the present time the New York Central & Hudson River R. R. Co., is operating forty-seven electric locomotives in the New York Terminal service. Of these, thirty-five were built in 1906 and twelve in 1908. They are all of the 115-ton 484 type and are each equipped with four GE-84 bipolar, gearless motors. The new electric locomotive adopted by the Company is likewise a bipolar gearless design, but it is equipped with eight GE-89 motors and is designated type 4444. Each motor is approximately three-fourths the capacity of the GE-84 motor used on the previous engines, making the aggregate capacity of the motors on the locomotive approximately 50 per cent. greater than before and affording approximately 25 per cent. higher speed.



End View of Electric Locomotive.

In general, the locomotive may be described as having an articulated frame with bogie guiding trucks at each end. The cab containing the engineer's compartments and that for the operating mechanism is swung between the two parts of the frame on the center pins. Each section is equipped with two two-axle trucks having a driving motor mounted on each axle. These cannot be distinguished as main driving or leading trucks, since all the axles are driving axles; but they are termed for clearness rigid trucks and swivel trucks respectively.

The rigid truck is built up of heavy steel castings, the side frames being of a truss pattern with heavy top and bottom members and pedestal tie bars. The end frames and center cross frames are steel castings securely bolted to the side frames and supporting the magnet poles. The magnetic circuit of each truck consists of the armatures mounted on the axles, the magnet poles carried on the end frames, the side frames and an additional magnet bar forming a path in parallel with the side frames. The

whole weight of the truck is carried on semi-elliptic and coil springs resting on the journal boxes and equalized together.

The main frame or backbone of the locomotive is a box girder built of 10-in. channels with ¼-in. top and bottom plates. It is approximately 10-in. deep by 36-in. in width and 22-ft. in length. The frame is bolted to the top member of the rigid truck, and extends forward over the center plate of the leading truck and backward to the heavy hinge which connects the two halves of the frame. The main frame carries in its top plate the center pin which supports the weight of the operating cab. All these center pins are hollow and serve as air passages, the main box girder frame acting as a distributing reservoir for the air delivered from the blower in the upper cab through the upper center pins and conducting it to the eight motors below.

The construction of the swivel or leading truck is similar to that of the rigid truck, except that it carries a center pin and is connected to the main frame through this center pin instead of being bolted rigidly to it.

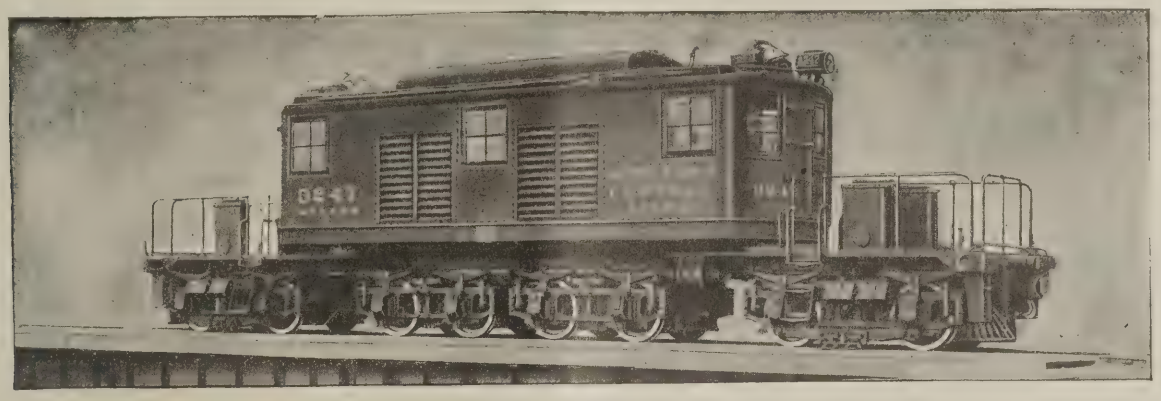
This type of design affords a long flexible wheel base with eight axles, but restricts the length of any rigid portion to not more than 6-ft. 6-in. All the axles are equipped with motors, but the magnetic circuit for each truck or pair of motors is self-contained and relates only to the two axles in that truck.

The cab, carried on the two center pins as stated, has its weight distributed between the two halves of the locomotive frame. It is the box type 35-ft. in length and 10-ft. wide. The interior is divided into three sections. A motorman's compartment is located at either end and contains the motorman's seat, controller, air brake, valves, bell and whistle rope handles, and such parts of the control apparatus as have to be within reach of the operating engineer. In the central section of the cab are the air compressors, blowers, contactors and rheostats, grouped so that they are conveniently accessible for inspection and repair, and separated from the direct reach or attention of the operating engineer. The advantage of this arrangement is that it removes from the sight of the engineer running apparatus which might serve to distract his attention from the actual work of handling the locomotive and which can be inspected and attended to by his assistant. This general type of construction leaves a fairly long platform on either end of the locomotive. Access to the cab is obtained through doors opening onto the platform.

The principal data and important dimensions applying to the locomotive are the following:

Length inside of knuckles	55-ft. 2-in.
Length over cab	33-ft.
Height over cab	12-ft. 8-in.
Height with trolley down	14-ft. 6-in.
Height with trolley running	15-ft. 1-in.
Width overall	10-ft.
Total wheel base	45-ft. 7-in.
Rigid wheel base	5-ft. and 6-ft. 6-in.
Total weight	200,000 lbs.
Weight per axle	25,000 lbs.
Dead weight per axle	6,395 lbs.

Taking up the specific features of the electrical equipment, the eight GE-89 bipolar, gearless motors each have the armature mounted directly on the axle. The field poles are carried on the truck frame, which forms the magnetic circuit. There are four independent magnetic circuits in the locomotive corresponding to the four trucks. The magnetic flux path on each truck passes in series through the fields and armature of one motor, through the center transom and the fields and armature of the second motor to the end frame, and then returns to the starting point through the two side frames and a reinforcing magnet bar lying parallel with the frames.



The Most Powerful Electric Locomotive in the World.

The motor is practically enclosed, and the field coils are waterproofed and armored. Each field coil is wound in a brass shell, the windings being in two decks of flat ribbon copper laid side by side. The outside turn is covered with insulation and an armor of sheet steel is clamped over it, filling the space between the sides of the shell in such a way as to protect the windings from water or mechanical injury. End shields are provided for each motor, which render it dust-tight and as nearly watertight as is possible in any motor designed with necessary outlets for forced ventilation.

Each motor at its one hour rating has a capacity of 325 amperes on 600 volts, or a continuous rating of 260 amperes on 600 volts under forced ventilation. For the complete equipment of eight motors, this corresponds to a capacity of 13,500 lbs. tractive effort at 54 miles per hour for the one hour rating, and 10,000 lbs. tractive effort at 60 miles per hour continuously.

The motors are electrically connected permanently in parallel in pairs, and the pairs can be connected in three combinations; viz., series, series-parallel and parallel. They are insulated for 1,200 volts, so that if at any future time it should be desired to operate the locomotive on 1,200 volts, the pairs of motors could be changed from parallel to series connections and the same speeds and control combinations obtained as on 600 volts.

The control equipment on the locomotive is the well-known Sprague-General Electric Type M and is designed to operate the eight motors connected in the three combinations: series, series-parallel and parallel. The external regulating resistance, divided into four parts, is directly connected, each part to a pair of motors permanently grouped in parallel. The pairs of motors with

their respective resistances are connected all in series on the first point of the controller. The resistance is varied through eight points on the controller and finally short-circuited on the ninth or running point. The pairs are then operated similarly in series-parallel with all resistance cut out on the seventeenth point. Finally all of the parts are connected in parallel with the twenty-fourth step a running point. This provides a control with nine steps series, eight steps series-parallel and seven steps parallel.

The transition between series and series-parallel is effected without opening the motor-circuit, and there is no appreciable reduction in tractive effort during the change. The smooth transition between points, both rheostatic and transitional, permits motor operation close to the slipping point of the wheels. The locomotive weight on the drivers is so proportioned that the motors operate safely up to the slipping point, which serves as a limit to prevent overloading the motors. The transition between all four pairs of motors in series to series-parallel is accomplished by short-circuiting two of the pairs of motors during the instant of transfer. The transition between series-parallel and parallel is effected by means of the standard bridge method.

The motor cutout switches are connected so that any pair of motors may be cut out of circuit. The locomotive will operate when a pair of motors is cut out with two groupings of the motors, the first with two pairs of motors in series and the second with three pairs of motors in parallel.

The protection of the locomotive against short circuits is very complete. All main fuse boxes are of the copper ribbon type, fitted with hinged covers to facilitate fuse renewals. The box is provided with a very effective magnetic blowout, which is energized by the current passing through the fuse. The main fuse boxes are located as near as possible to the overhead trolley and to the third rail shoes in order to protect the wiring circuits near the source of supply. Each pair of motors is locally protected by a fuse box. The main switch is provided with a blowout so that heavy currents can be opened without damage.

An ammeter is located at each engineer's position and records the current in the circuit of one pair of motors. The ammeter and air gauges are illuminated by a gauge light connected in the headlight circuit, so that the headlight switch turns on simultaneously the headlight and the gauge light at the same end of the locomotive.

The main motor rheostats are formed of cast iron grids mounted in a frame and insulated in mica. The rheostat boxes are assembled in the monitor deck of the locomotive.

Current is collected by eight underrunning third rail shoes, or by two overhead trolleys when on gaps on the third rail. The overhead trolleys are the pantograph type and are pneumatically operated. They can be put into service from either engineer's position by a foot-operated valve. The trolley is designed for intermittent use and is therefore arranged to be held in a raised position only while the valve is held open by the engineer's foot.

The headlights are the incandescent type with parabolic reflectors 16-in. in diameter. The interior illumination of the cab is provided by ten incandescent lamps arranged in two circuits, two lamps being located in each engineer's cab and the balance in the central compartment. In each lamp circuit is a portable lamp with extension cord 25-ft. long. One lamp switch is located in each engineer's compartment, so that from either end of the locomotive the lamps can be controlled in that compartment, as well as half of the lamps in the central compartment.

Electric heaters are placed in the two engineer's compartments. The heaters are a standard electric car type, fitted with especially heavy outside covers to protect them from the mechanical injuries to which they are exposed in locomotive service.

The blower set provided for ventilating the driving motors is located in the central compartment. The blower has a capacity of 24,000 cu. ft. of air per minute and is driven by a series wound motor of the railway type.

The air compressor is the CP-26 type. It is a two-stage motor driven compressor with a piston displacement of 100 cu. ft. of air per minute when pumping against a tank pressure of 135 lbs. per square inch. The air is taken from the interior of the central compartment through a screen, which prevents the entrance of particles of dust. The compressed air in passing from the low pressure to the high pressure cylinder is conducted through radiating pipes under the platform of the main cab. This reduces the temperature of the air and allows condensation of moisture before entering the high pressure cylinder. From the high pressure cylinder it is delivered into a series of air reservoirs. There are four of these, each 16-in. by 90-in. They are located under the floor of the cab and connected in series, which provides a further opportunity for radiation and condensation.

Leach type L double pneumatic sanders are provided. The sander valves are located within convenient reach of the engineer's seat, and valves and sand boxes are arranged for sanding the track in front of the leading wheels when running in either direction. The bells are fitted with Sampson automatic bell ringers. All wiring is drawn through conduits and is carefully protected from mechancial injury.

ELECTRIFICATION COMMISSION.

At a recent meeting of the New York railroad club, Mr. F. J. Sprague outlined a plan for a technical committee to aid steam railroads in choosing a proper system of electrification, and in the purchase of electrical energy and equipment.

The speaker stated that if this big problem could be referred to a committee of representative engineers who would occupy a confidential position with reference to both manufacturing and railroad interests and who would have available the entire experience of the large manufacturers in the design of equipment, as well as the complete operating data of railway installations already in service, some effective results might be obtained.

Even assuming that the superiority of any one system is definitely established and that ultimate economy of operation and increase in capacity effected by electric traction is well established, the problem of financing the project is a very serious one. Where a reliable supply of energy at a reasonable rate and with ample reserve is available from outside interests, the problem of electrification then resolves itself simply into the construction of electrical locomotives and transmission equipment along the right of way.

In conclusion Mr. Sprague stated that the principle manufacturing companies are now favorably disposed toward the establishment of a technical commission, to be composed of six expert engineers of wide experience, who shall make a thorough study of the various systems of electrification. They are prepared to bear

in part or if necessary to meet the entire expense of such a commission.

They also favor some scheme of financial development which shall relieve the railroads of part of the great burden of electrification.

When the co-operation of the proper railroads is obtained the possibilities of this technical commission will be realized and the excessive costs of mistakes in individual judgment of any one road will be avoided.

SCHOOL OF ELECTRICITY.

Realizing the great importance of electricity in all branches of railroad operation at the present time and with the future possibility of very extensive electrification of terminals and main line divisions, the Pennsylvania railroad have very recently established a free course of correspondence in electrical engineering under the supervision of Mr. J. C. Johnson, Supt. Telegraph. Already over 10,000 have been enrolled and the course will undoubtedly do a great good in training the employees in the fundamentals of electricity.

It will be conducted as a correspondence course and a series of instruction papers in pamphlet form will be issued. The course will include elementary mathematics, mechanical and geometrical drawing, magnetism and its application to electric generators, motors, measuring instruments, telegraph, telephone, signaling, lighting, traction and general equipment. The course will cover elementary work in both alternating and direct current apparatus. Besides providing for the education of employees in practical electrical equipment this course will be used to train a large number of men for the duties which will devolve upon them when electric traction is extensively applied in railroad service.

Students are invited to ask questions and a course of supplementary reading of text books and periodicals is recommended. The first lesson of this course covers the subject of elementary arithmetic. This will be followed by pamphlets on primary cells, direct current and magnetism. There will be fourteen lessons in the entire course, concluding with electric traction and power plant design.

C. M. & ST. P. RY. ELECTRIFICATION.

As previously announced the Chicago, Milwaukee and St. Paul Railway are to electrify a portion of its main line through the Rocky Mountains between Harlowton, Mont., and Avery, Idaho, a distance of 440 miles. Engineers of certain electrical manufacturing companies are now working on the plans for this installation which are expected to be finished about the middle of 1914. It is estimated that 2½ years will be required to actually complete the construction work after the final plans have been fully approved. This is the first trunk line electrification which is to cover entire engine divisions and for this reason the development of this project and the operation of the electrified section when complete, will be followed with a great deal of interest. There are three mountain ranges included in this electrified section, although the grades are not very severe, there being but 20 miles of 2% grade and 24 miles of 1.7% grade. The most difficult feature of electrification, however, is presented by a continuous grade of 1% for 44 miles on the western slope of the Big Belt Mountains and the successful solution of this problem will undoubtedly mark an important advance in this field.

One of the important advantages gained from this proposed electrification will be the elimination of the yards at Three Forks and Alberton. These are stations about 100 miles from each end of the electrified section which mark division points for change of engine crews and require extensive yard trackage. It is planned to double up on the length of the divisions by running the electric locomotives continually for about 220 miles, covering two of the present divisions and changing engine crews midway.

Power will be derived principally from the Great Falls and Thompson Falls power developments although these plants are connected with a number of others, so ample power is available. A permit has been granted by the Government to the Great Falls Power Company to construct a transmission line across public lands to carry power for this electrification. The details of the plans for this big electrification project will be announced later.

ELECTRIC LIGHTING OF STEEL PASSENSER CARS.

Mr. H. A. Currie, Asst. Elec. Engr. of N. Y. C. & H. R. spoke on the subject of electrically lighted steam cars before the recent meeting of the American Institute of Mechanical Engineers. He said that from a standpoint of practical consideration for the welfare of passengers, the lighting plays one of the most important parts; therefore, every effort should be made to arrange the light units so that discomfort be occasioned, and to install the apparatus and wiring so that operating failures be reduced to a minimum.

The two essential considerations for the designing engineer to keep in mind in laying out his installation are : (*a*) The arrangement of parts in a manner to allow of easy inspection and repair. (*b*) Protection against mechanical injury. Convenience and accessibility of apparatus, fixtures, junction boxes and wiring mean much to the inspector. It is well known that the average inspector will pay little attention to those parts which are difficult of access, and much better inspection work will result where parts are arranged in a get-at-able manner. It is of equal importance that the various parts be protected in such a manner as to avoid all possibility of injury to them while the car is in service.

It would be a consummation much to be desired if truck designers would provide a generator support built integral with the truck; the requirements are not difficult and it is certain that the generator builders would be glad to make their machines conform to the truck builder's suspension. As the matter is now handled, nothing causes them more delay and inconvenience than obtaining information about the numerous details of truck and underframe construction necessary for making an intelligent layout of the generator suspension.

NORFOLK & WESTERN TO ELECTRIFY ELKHORN BRANCH.

The Norfolk & Western Ry. has announced that it will electrify its Elkhorn branch, from Eckman to Bluefield, W. Va., a distance of 27 miles. Preliminary work in connection with the project is now under way, but the plans are not sufficiently advanced to give out details. This part of the road includes very heavy grades through a mountain country and carries an extremely heavy freight traffic. The road has been negotiating for power with the Appalachian Power Co., which operates hydro-electric plants in the vicinity.

The New E. S. B. Car Lighting System

The Electric Storage Battery Company of Philadelphia have just placed on the market a new axle lighting system which will be of special interest to car lighting men as it contains many novel points in its design and operation. The manufacturers state that it is a constant voltage rather than a constant current system and is designed particularly with a view to simplicity, reliability, minimum attention and maximum battery life. The dynamo is of the Rosenberg type which has been used very extensively abroad for a number of years in lighting railway cars. This generator, however, has been largely redesigned by the Electric Storage Battery Company to operate in connection with a special constant voltage regulator.

Generator.

The Rosenberg generator is a very interesting one to the student of electrical equipment, in fact, might be called a freak generator, for what is ordinarily understood as the terminal brushes of the machine B_1, B_1 are completely short circuited and the external circuit is fed from an auxiliary pair of brushes B_2, B_2, which make contact with the armature coils as they pass across the center of the generator pole pieces.

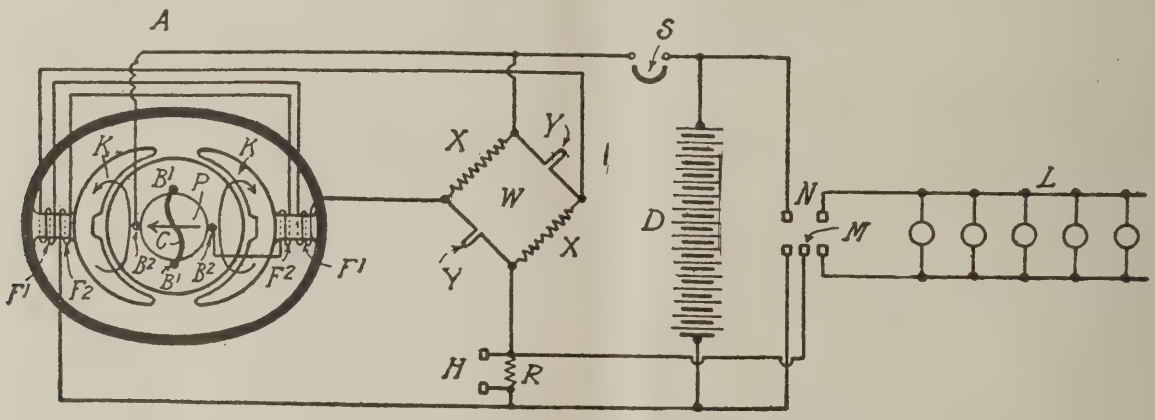
Current flowing through the primary field winding (F_1) produces a small primary field flux represented by the arrow (P). This introduces a small electromotive force between the two short circuit brushes (B_1), causing a fairly heavy short circuiting current to circulate through the armature coils. This current produces a strong auxiliary, or secondary, field which is perpendicular to the primary field flux. This secondary magnetism does not pass through the generator frame, however, but simply circulates through the armature core and heavy pole shoes as indicated by the arrows (K).

This magnetism creates the principal field of the generator and produces the required electromotive force at the external circuit for the brushes at (B_1 and B_2). A series of field winding (F_2) serves to counteract the distortion of the field due to armature reaction as the load comes on the machine. This being 90 degrees in position from the principle magnetic field of the machine, creates a magnetic flux which is directly opposite to that of the armature reaction created by the external circuit current passing through the armature coils. Moreover, the winding of this series field is made so as to exactly balance the distorting effect of the generator field and entirely eliminate sparking of the brushes due to shifting of the field. In this respect the series winding of this machine is identical with the "interpole" which has been so successfully applied to generators and motors recently.

Another important advantage of this machine is the fact that it generates the same polarity whatever be the direction of rotation, thus requiring no pole changer. The explanation of this is at once evident, for since the permanent magnetism is always maintained in the same direction, a reversal of the direction of generator rotation will cause the short circuiting current between the brushes (B_1, B_1), circulating through the armature coils, to reverse. Thus the principal field magnetism of the machine will be reversed on reversing the direction of motion, and this will then provide the same polarity to the external circuit at all times.

Automatic Switch.

The automatic switch contains a new feature, for instead of the generator closing at a certain voltage regardless of what the battery voltage is, it is arranged to close when the generator voltage exceeds the battery voltage by a slight amount. This will eliminate the jump in voltage sometimes noticeable when an axle equipment cuts in. The switch is also adjusted to open when the output of the dynamo drops to zero.



Wiring Diagram of New E. S. B. Car Lighting System.

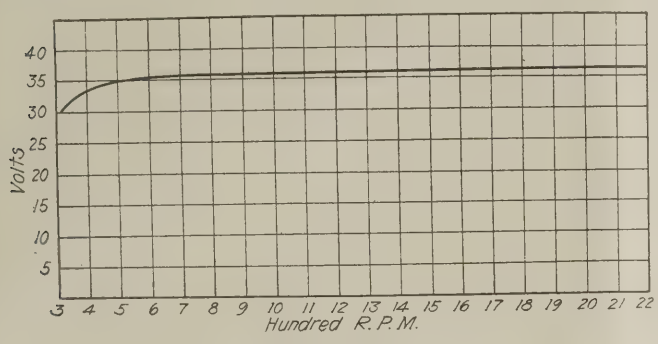
Constant Voltage Regulator.

The primary field winding F^1 is connected across opposite junction points of the Wheatstone bridge W, the other two junction points being connected respectively to the positive and negative terminals of the machine. This bridge is designed to give the constant voltage characteristics above mentioned. It includes fixed resistances X in opposite branches and iron wire ballasts Y in the other two branches. The latter, on account of their high temperature coefficient, have a practically constant current characteristic under operating conditions. This combination of circuits produces a field of excitation continually diminishing with increase of speed. The resulting speed voltage characteristic of the dynamo is shown in Fig. 2.

The voltage of the dynamo is fixed at a point slightly above the floating voltage of the cells, thus insuring that the battery is always fully charged. The differ-

ence between its voltage and that of the battery on discharge is stated to be so small, however, and the change from one to the other so gradual that no lamp regulator is required.

Should it ever be found necessary to give the battery a high voltage charge, this may be done during a daylight run by means of the fixed resistance (R), normally short circuited by the switch (H) and also by the clip (M) on the main lamp switch. When both of these switches are open, the voltage of the dynamo is raised by an amount determined by the value of the resistance (R). Whenever lights are required, the closing of the lamp switch (N) short circuits the resistance (R), reducing the voltage to normal and eliminating the possibility of excessive voltage of the lamps. During five months of continuous operation of this equipment, however, no occasion for such a high voltage charge has arisen.



Characteristic Curve Showing the Regulation.

This system automatically adjusts the output of the dynamo to the requirements of the service, and gives the battery the slight amount of overcharge required to keep it practically full and in good condition. Should the battery become discharged by a prolonged stop with lamp load on, its charge will be rapidly restored during the subsequent run by a fairly heavy charge immediately on picking up speed. Although this is a constant voltage machine, the output of the generator and the charging rate is limited to a reasonable value by means of the differential series coil on the generator primary pole pieces. Should the car be transferred from a daylight run to one requiring considerable artificial lighting, the output of the dynamo will increase to meet the changed conditions of service. This is all accomplished automatically without manual adjustment of any kind.

OPERATION OF BALL BEARING GENERATORS.

Safety Car Heating & Lighting Co. give some interesting information on the subject of ball bearing maintenance. A safety generator with Hess-Bright ball bearings went into service July 20, 1911, and the car on which this generator was constantly used made a total of 137,933 miles to March 7, 1913, when the bearings were removed for measurements.

These measurements are as follows:

Bearing on Pulley End.

Radial freedom; that is, freedom at right angles to the axis of the shaft..... 7/10000 ins.
Endwise freedom, or axial freedom.....10/1000 ins.
Eccentricity, inner race revolving..... 5/10000 ins.

Bearing, Commutator End.

Radial freedom .....10/10000 ins.
Endwise freedom .....13/1000 ins.
Eccentricity freedom ..... 3/10000 ins.

The freedom tolerances for new bearings are:

Radial freedom ..... 2/10000 ins.
Endwise freedom ..... 5/1000 ins.
Eccentricity ..... 3/10000 ins.

Therefore the wear in 137,933 miles service travel has been:

Bearings, Pulley End.

Radial wear ..... 5/10000 ins.
Endwise wear ..... 5/1000 ins.
Eccentricity ..... 2/10000 ins.

Bearings, Commutator End.

Radial wear ..... 8/10000 ins.
Endwise wear ..... 8/1000 ins.
Eccentricity ..... none.

LONG RUN OF A STORAGE BATTERY CAR.

A new Edison-Beach storage battery car recently made a trip of 310 miles from New York to Boston, via the Hudson River and Boston and Albany routes. Various Boston and Albany officials made the trip with the car including Mr. E. J. Wright, general superintendent; C. F. Smith, general superintendent of passenger transportation; L. E. Vosburgh, general passenger agent; G. H. Wilson, superintendent of the electric division; C. K. Broadhead, trainmaster of the electric division; E. B. Katte, chief engineer of electric traction, all of the New York Central Railroad, and Mr. R. H. Beach, of the Federal Storage Battery Car Company, acted as host of the party.

The test was a very interesting one as it offered a long run on a practically level grade, climbing a high range over 2 per cent grade and considerable curved track. The car which made this run is 50 ft. long over all, 12 ft. 6 in. high and 8 ft. 11 in. wide. It conforms to M. C. B. equipment interchange specifications and weighs complete with load 34.6 tons. Seats for forty passengers are provided in the main compartments and for ten passengers in the baggage compartment. On the trial run the car carried a combined live and artificial load equivalent to the weight of eighty-four passengers.

The electrical equipment of the car includes four 20-h. p. 220-volt Diehl motors and two sets of 230 cells, each of Edison A-8-H storage battery, delivering current to the motors at approximately 240 volts.

Following are some of the more important data taken from the official report of the test.

Weight of standard battery.....8,525
Weight of auxiliary battery.....8,525
Total tons 34.37
Overall length of car.....50 ft. 3 ins. over couplers
Width of body.....8 ft. 10½ ins. over sheathing
Height of body.....11 ft. 10 ins. from rail to top of roof; 12 ft. 6 ins. to top of ventilators
Size of wheels.....33 ins.
Number of motors.....4
Rating of motor.....200 v. 75 amp. 700 r.p.m.
Type of battery.....Edison—A/8/H
Number of cells.....250 in each set
Actual running time.....11 hrs. 6 mins. 51 sec.—11.115 hrs.
Total distance (from time table).....306.71 miles
Average miles per hour..... 27.6
Total number kilowatt hours.....309.1
Average k.w. hrs. per car mile..... 1.2
Average k.w. hrs. per ton mile..... .035
Total ampere hours..... 4.25
Maximum speed .....42 M.P.H.
Total charging time on run.....3 hrs. 27 mins. (3.45 hrs.)
Total ampere hours from charging.....275

The batteries were fully charged when the car left New York, and the run of 114 miles to Hudson was made at an average schedule speed of 35 m. p. h.. On

arrival at Hudson the car climbed 1½ miles of 2 per cent grade before recharging. The energy consumption for the level run of 114 miles over the main line of the New York Central was 37½ watts per ton mile. Through the courtesy of the Albany & Southern Railroad, the battery was recharged from that company's third rail and then the run toward Boston was continued. The car arrived at Springfield, Mass., 98 miles distant from Hudson, with about one-third of the full charge left in the batteries, and this after having climbed the Berkshire Hills to an elevation of 1,450 ft. and negotiated many grades, including one continuous up-grade of 1 per cent for 8 miles.

The battery received a short boosting charge at Springfield while the party had dinner. The remainder of the run, 98 miles, to Boston was covered without event.

Ball Bearings

A Talk by Mr. W L. Batt Before a Special Meeting of the Pioneer Train Lighting Association, St. Louis

I consider it an opportunity to talk to you gentlemen on the subject of Bearings for axle generators, since it is you who come in closest touch with these bearings.

In a brief talk I want to show you that a ball bearing is the most reliable form of axle generator bearing and explain something of what is necessary to obtain the best results from it.

Let us consider the service under which the bearings on an axle generator operate. The machine extraordinarily heavy for its output is hung directly on the truck frame and driven by a heavy double belt to which any amount of tension may be applied. It is subject to an enormous amount of shock as the truck passes over the roadway and large end thrusts are imposed on the bearings as the truck sways from side to side. A very severe bearing condition is further brought about as the generator hammers backward and forward due to the play of the driving axle box in the pedestal way.

When one compares this severe service with that of the ordinary generator, it is not difficult to see why the plain sleeve bearing with nothing more substantial than a thin film of lubricant separating the fast moving and the fixed surfaces, is such a frequent source of trouble. You are familiar with the various attempts made to improve the sleeve bearing to a point of reliability. The grease lubricated bearing; the oil bearing; the oil and waste and many modifications have been tried with varying success. Such remedies only palliated the evil—it was apparent to thoughtful engineers that the sliding of one part in another with the imperative necessity for a thin film of lubricant must be done away with. The solution is found in the Hess-Bright ball bearing with which many of you are familiar. It can be easily applied to a machine, simply removed; it requires only the most occasional attention and will safely carry, for many years, all the load and shock which may ever come upon it. Its life will not be materially affected by any belt tension which may be put upon it and a lapse in inspection or lubrication, while not to be commended, will ordinarily cause no trouble.

It is probably difficult for you to see why a ball bearing can thus carry loads which the plain bearing, with its long so-called surface contact is unable to carry. You, perhaps, think of the axle generator ball bearings in terms of the too-familiar bicycle bearings which were prolific of trouble without end and yet the ball bearing with its freedom from friction, made the bicycle possible.

Let us first take up the construction of the Hess-Bright ball bearing with the development of which I have been associated for many years.

It consists of two hardened rings and a series of balls rolling between. The inner ring, or raceway, is a snug fit on the armature shaft and rotates substantially as a part of that. The outer raceway is a slip fit in the housing and is stationary. Between these two paths of hard, tough alloy steel, and in deep grooves, the balls roll. It will be readily apparent to you that because of these grooves a full circle

Fig. 1. Hess-Bright Ball Bearing, Railway Type.

of balls cannot be put in. As many as possible are put in by holding the two rings eccentrically together; the balls are then spaced evenly, and a heavy manganese bronze ring in halves, but with pockets for each of the balls, is inserted and the halves riveted together.

This then results in a heavy rugged unit, capable of carrying large amounts of end thrust as well as radial load. The balls do not carry load on points as is frequently suggested, but on very substantial areas of contact. They roll truly and the friction loss is slight. For all axle generator work, one size of bearing, the No. 412, is used by all manufacturers on all types of machines and on both ends of each. This is in order that it may not be necessary for your companies to carry a wide stock of bearing sizes as you do now of pulleys and plain sleeve bearings. The bore of this bearing is 60 m/m or 2.3622, the outside diameter 150 m/m or 5.9055 and the width 35 m/m or 1,3780. The Hess-Bright bearing contains balls 1- 1-16" in diameter—each of which requires the enormous load of 90,000 lbs. before crushing. The cut in Figs. 2 and 3 shows very clearly the method of application of the bearings to a generator.

Two complete bearings are used on each machine, one on the pulley end and one on the commutator end. These are, as stated before, of the same size. The method of mounting on different types of machines vary considerably. In Fig. 2 shown herewith, the bearing on the pulley end is solid on the shaft, the inner race being confined between the shoulder and a nut rigidly locked. The bearing on

the commutator end is on a straight keyed sleeve, the hole being locked up by a nut. Another form of application consists in carrying the pulley end bearing on a sleeve which is locked by the pulley and that in turn by the nut on the end of the armature shaft. This is for greater freedom in removing the bearing. Where the bearing is tight on the shaft, occasionally some difficulty is experienced in freeing it.

The bearing on the commutator end of Fig. 3 is

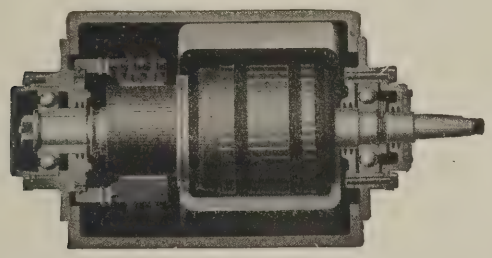


Fig. 2. Safety Generator on Hess-Bright Bearings.

held on a taper bushing, as it is frequently urged that a taper bushing may be more easily removed from the shaft than a straight bushing. You will notice that grooves are employed in the caps where the shaft passes through to better retain lubricant and on the back end of the machine, next to the pulley felt is used although this is rather indistinct in the illustration. This is a further means of protection and provision against the entrance of foreign material from the outside. When grease pipes are employed

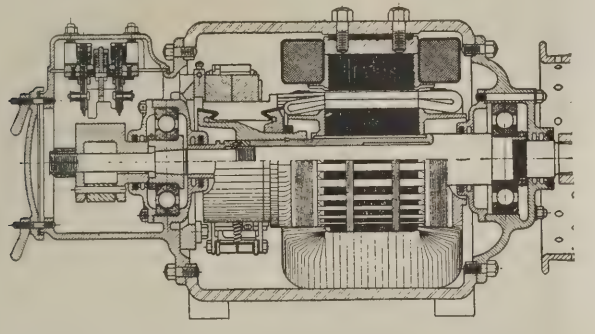


Fig. 3. Gould Generator on Hess-Bright Bearings.

they usually lead off horizontally or at a slight angle to the horizontal, on the side of the machine opposite to the belts. They are capped in some appropriate manner. You will see that considerable space for lubricant is left available. The housing should never be entirely full of grease but rather from ½ to ⅔ full.

In lubricating ball bearings, you should use grease that contains no free acid and one that will not become thin in service. You will readily see that grease containing acid would quickly attack the finely polished surfaces of the balls and races. When this smooth surface is destroyed, the friction will be enormously increased and finally the balls and races ruined. A grease that becomes thin in service would do no harm to the bearing itself, but would merely run out of the housing into the generator frame and be lost.

Be sure that the bearing housing is properly filled with lubricant when the equipment goes into service, then watch the bearing to see how much is being actually taken up. Do not go around with a grease gun every time the car makes its appearance and force in some grease. If you do, the result will be that the grease is merely forced into the machine because the housing can only hold a certain amount.

The equipments as put on the market have a ⅜" pipe to which the grease gun can be attached but this has been found to be too much of a temptation for many men, as they feel that they would rather grease too much than too little and when there is ready means of greasing, they will use it. On that account some have entirely removed the pipe and lengthened their lubricating periods to four or six months, at such times they entirely remove the machine and clean out the bearings and add a new change of fresh grease. Where an equipment is always on its home road this is feasible and very desirable. It will be a matter of experiment with each road just how often the machines should be greased. If you find grease in the body of the machine, you know that you are greasing too often and the periods between greasing can be lengthened. Really, the best way to ascertain how much grease is in the bearing is to remove the cap, then if there is not enough in it, some can be added. When you remove the bearing cover on the end of the machine, you must be very careful not to allow any dirt to fall into the bearing. If you take it off and lay it on the right of way and put it back without cleaning it out, you will probably get cinders into the machine. Naturally the cinders will not do the balls and raceway any particular good. I am emphasizing this, for such things may happen as there are careless and thoughtless men who will not realize the necessity of keeping the bearings clean. If you will keep a bearing clean and grease it occasionally, I am positive you will get almost perfect results.

Discussion.

MR. FRANK:—I would like to ask a question as to how you may test for the amount of grease in the bearing. We have no record as to when the machines were greased and I do not know just how to make a positive test.

MR. BATT:—If you take the cap off the commutator end and find that there is plenty of grease in the bearing, there is no need of adding any more, but if you find it practically dry, of course, it will be necessary to add the proper amount. I spoke of taking the cap off the commutator end as that is more accessible, and no doubt, conditions are the same at both the commutator and pulley end. If there is grease in the commutator end, there will be grease in the pulley end and vice versa. I am not in favor of grease gun lubrication. I know machines are being run without taking off the caps for six months. I think this is as long, however, as they should go.

MR. HALM:—I might suggest that you explain how the armature is taken out.

MR. BATT:—That will depend entirely upon the type of machine which is being considered. In Fig. 2 for instance, the armature would necessarily be removed from the back end. The best means would probably be to take off the cover on the commutator end by removing the small studs, shown in the cut, then taking the nut from the end of the armature. Going to the back end of the machine it would then be necessary to remove the large screw bolts which hold both the front and back cap and to then pull off the housing. When that is free the armature may then be removed, carrying with it the ball bearing on the pulley end, together with the cap which will be loosely on the shaft inside of it and leaving the bearing on the commutator end in the housing. This

is only typical explanation because different types of machines will require altogether different treatment. The only difficulty which is apt to be encountered in this particular type of machine is in removing the bearing itself from the armature shaft, in case that should be necessary. It is for that purpose, that in many cases the bearing on the pulley end has been put on a sleeve so that it may be more freely withdrawn.

MR. DIENSBACH:—What is the effect if the grease becomes heated?

MR. BATT:—It begins to soften when the machine becomes heated. Any grease will begin to soften at certain temperatures. The average grease melting point is 190° F. I do not know of any one that has taken any temperature tests of ball bearing housings in service but know it is well below that point.

MR. ELBREDER:—What grease do you recommend?

MR. BATT:—Many of the railroads are using Robinson & Sons, Greoil, with very good results

MR. BATT:—If there are any further questions regarding ball bearings, I will be glad to answer them. This is a new Association You can gain a lot of knowledge and information, simply by talking over various subjects among yourselves. Then it gives us supply men an opportunity to get acquainted with you. While this is a new club, and to my knowledge the only axle light club in this country, I think you have started a good move, particularly because of the fact that many railroads enter here. In Philadelphia we could not have a club of this kind as there are only two railroads.

I wish you all sorts of success. At one time the Master Car Builders' Association was not as strong as it is today. The Association of Railway Electrical Engineers is made up of your representatives and they have got to be supplied with material, ideas, questions, etc., and unless they get this information from you, where else are they going to gain it? I want to thank you for your attention and I again wish you all sorts of good luck and success in the future.

Before stopping I would like to say that I have a little booklet which I got up for the Convention at Chicago, and if any of you gentlemen would like to have a copy of same, if you will give me your name, I will see that you get one.

PRESIDENT:—Gentlemen, if you have any questions to ask, get up and state them, as Mr. Batt will gladly answer them.

MR. REED:—I make a motion that we give a vote of thanks to Mr. Batt for giving such valuable information on ball bearings.

MR. BIRCH:—I second that motion.

Vote unanimous.

MR. BATT:—If you will take reasonable care of the ball bearing equipments I will consider that the best sort of thanks.

Motor Talk No. 7

ALTERNATING CURRENT MOTORS. (Continued.)

In the two preceding Talks we considered some of the more important elementary features of alternating current motors in general, so let us now discuss the various types of a. c. motors in a more detailed manner.

There are two general types of a. c. motors in common use today, those which run at a fixed speed regardless of load and called "synchronous motors," and the other and much larger class called "induction" or asynchronous motors, whose speed varies slightly with the load. It is this latter class which is used to drive machine tools of nearly all kinds, so we will give that type first consideration.

Induction motors are made for use on all systems of distribution, single-phase, two-phase, three-phase, etc., and for all commercial voltages and frequencies, but the majority are three-phase because they offer several advantages over the other forms and are simple.

Single-phase induction motors are less economical than three-phase motors as to both first cost and operation, and are not so satisfactory with respect to no-load current, powerfactor, overload capacity or starting torque. Quarter-phase or two-phase motors are not desirable because of the added complication due to the control of a four-wire system and very few two-phase circuits have been installed.

Polyphase or multiphase induction motors consist of the usual stationary element or stator and the revolving element or rotor. There is no electrical connection between the stator and rotor, as with direct current machines, the action being magnetic like that in a transformer and as described in the March issue of this paper.

The speed of induction motors is very nearly constant, being fixed by the number of poles and the frequency of the circuit, but falls off slightly under loads. As the load increases the speed is reduced more rapidly until the point of maximum capacity (break-down point) is reached when the speed suddenly drops to zero. Whenever possible, high speed induction motors should be used because their operating characteristics are better and they cost less than slow speed motors of the same capacity.

The two general types of constant-speed induction motors are known as the "squirrel-cage" type and the "wound-rotor" type. The first is so named because the armature conductors consist of copper bars laid in the slots and short-circuited together at each end by copper rings, so they would look somewhat like a cage if considered separate from the armature core. The wound-rotor type takes its name from the fact that the conductors are wound separately on a form, similar to the coils for a direct-current armature, before being placed in the slots. The coils are then connected to collector rings around the shaft at one end, similar to a. c. generators, and are supplied with brushes to which the motor currents are led through a suitable resistance and controller from the line.

This resistance may be designed to stay in circuit continuously, where a reduction of speed may be necessary, or it may be arranged for starting duty only

and cut out after the motor is up to speed. Wound-rotor motors may be built for either constant or variable speeds whereas squirrel-cage motors are generally used for constant speeds only.

When choosing a constant-speed induction motor for some particular service there are several points to consider. The standard squirrel-cage motor has no moving parts carrying current, hence is suitable for dirty or dusty locations or where sparking would be dangerous, but it has the disadvantage of a comparatively low starting torque per ampere of current required. Such motors will draw from the line, for a few seconds while starting, several times the normal full load current in order to develop the equivalent of full load torque. If the motor is very large this is likely to cause a line disturbance that will affect other apparatus, especially any lamps which might be on the same circuit.

Only the very smallest squirrel-cage type motors should be switched directly onto the line, the rush of current with larger ones demanding the use of a suitable starting device or an auto-transformer to reduce the impressed voltage when starting, and consequently limiting the current. The starting torque will be reduced more rapidly than the current, however, because the torque varies in proportion to the square of the voltage while the current varies directly as the voltage. That is, if your voltage is reduced to one-half, the torque will be reduced to one-fourth but the current will be reduced to only one-half that due to full voltage. If it is necessary to develop a large starting torque a comparatively large amount of current must be taken from the line, so the voltage should not be reduced unless it is necessary to limit the maximum current used. The maximum torque of induction motors is usually two or three times the full load torque, and this is true of both squirrel-cage and wound-rotor type motors.

It is evident from the foregoing that the important point to consider when choosing an induction motor is its starting torque rather than its maximum torque, this being true for either type. Where the starting duty is severe and there is an objection to a large starting current, a wound-rotor motor is particularly suitable. The starting current necessary to obtain the equal of full load torque would be only a little greater than full load current, whereas a squirrel-cage motor will take four or five times as much. The efficiency is slightly less than that of a squirrel-cage motor because of greater losses in the rotor, and the "slip" or drop in speed from no load to full load is somewhat greater.

Where the use of a wound-rotor type motor is not desirable, such as in dirty locations, etc., and yet a high starting torque is necessary, a squirrel-cage type motor with a high resistance rotor may be used. This usually means that the short-circuiting rings at each end of the armature conductors are made of small enough section (or low conductivity material) to increase the resistance to the required amount. In commercial motors the torque at starting is, up to a certain point, proportional to the rotor resistance (as previously stated) hence increased torque may be obtained by the method stated.

The next Motor Talk will deal with Single Phase Motors.

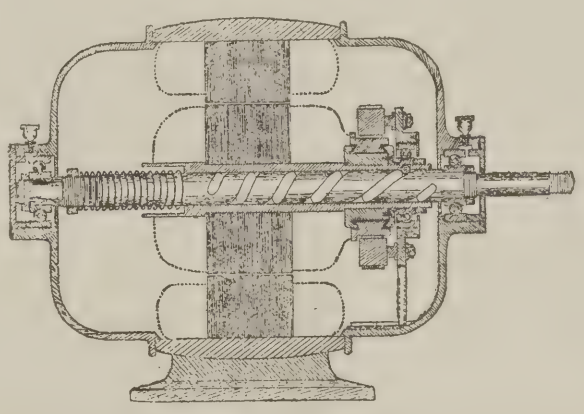
CLOTH PINIONS.

The General Electric Company has just issued a new bulletin on "Cloth Pinions." While this bulletin, No. A4110, supersedes the company's previous bulletin on this subject, it contains additional data relative to tooth dimensions and instructions for the selection of pinions.

A NEW SELF-REGULATING DYNAMO.

The *London Electrical Review* publishes a description of a new self-regulating constant current dynamo recently devised by Mr. A. A. Price, of London. The principle of the construction is shown in the accompanying diagram.

The armature and brush gear is built up on a sleeve which is mounted on the shaft, and driven by balls which engage in spiral grooves cut in the shaft; the armature is held in position between the pole magnets by a coil spring, which is partly recessed in the sleeve. the tension of which is adjusted by a nut. When the dynamo has attained a speed sufficient to give the required output, the reaction between the armature and the field magnets will cause the armature to wind



Sectional Diagram of Self Regulating Dynamo.

along the shaft and partly compress the spring, leaving its normal position and moving to a region where it is traversed by a smaller magnetic flux, thus automatically taking up a position compensating for the increase of speed. The same action takes place on reduction of speed, but in the opposite direction, the armature winding itself back into a stronger field. It is claimed that the voltage remains constant from 800 to 3,800 r.p.m., and the machine is specially suitable for the lightning of motor vehicles; it is very economical in its action and can be constructed for either a forward or reverse drive.

NEW RAILROAD BUILDINGS AT UNIVERSITY OF ILLINOIS.

The University of Illinois, which has for years devoted much attention to the subject of railroad problems, both of equipment and operation, has recently completed a new Transportation Building and new Locomotive and Mining Laboratories which was formally dedicated on May 8th and 9th. A large number of invitations have been extended to everyone interested.

Various prominent railroad officials and public men will deliver addresses, among whom are Mr. Samuel Insull, president Commonwealth Edison Co., Chicago; Mr. J. G. Panghorn, special representative, Baltimore & Ohio R. R., Baltimore, Md.; Mr. C. B. Young, Mechanical Engineer, Chicago, Burlington & Quincy R. R., Chicago; Governor Edward F. Dunne, and Mr. C. H. Markham, president Illinois Central R. R.

Lesson No. 16

Axle Lighting

KENNEDY REGULATOR.

This regulator was placed on the market by the Consolidated Railway Electric Lighting and Equipment Company in 1906 and has been in successful operation on a large number of cars since that time. This was the first equipment to employ a special lamp voltage regulator which was entirely independent of battery condition or number of lamps in use, and the manufacturers of this equipment deserve credit for the advanced stand they took in the matter at that time.

Machine Regulator.

Although this regulator was an entirely new design it contains many of the fundamental principles underlying the operation of the old type "A" regulator. The regulator controls the generator on practically a constant current basis although this is slightly modified as explained later. The generator output is controlled by varying the generator field resistance. A small motor operates a cam shaft through a worm gear as shown in Fig. 89 in somewhat the same manner as on the old type "A" equipment and the control is effected by means of the pair of solenoids shown on the right hand side of Fig. 89.

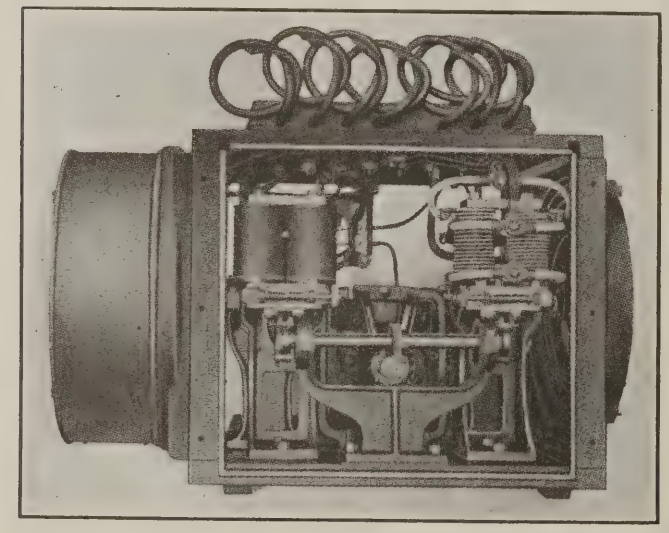


Fig. 89. Regulator with Cover Removed. Lamp Regulator Coils on the Left and Machine Regulator Coils on the Right.

It will be noted that there are two cam followers, one above and one below each cam with a slight clearance between. These cam followers are attached directly to the floating plungers of the two small solenoids above and when the output is too high the lower follower will be drawn into contact with the revolving cam and will turn one of the pair of ratchet wheels shown on the left hand side of Fig. 91, operating the field resistance arm which cuts in generator field resistance and so reduces the generator output. The magnetic pull of the solenoid is balanced against the adjustable pull of a spring. This spring is of fairly heavy bronze wire and the adjustment is made by twisting the spring. The initial adjustment is made at the factory and a small dial with various ampere settings and indicating arrow is mounted at one end of the shaft. The regulator can then be set at any desired output as indicated on this dial without actually testing the machine on the road.

It will be noted that there are two windings on each current solenoid. The main generator current passes through the heavier winding and the generator lamp current through the smaller pair of coils. These coils are wound so that the magnetism of the lamp circuit coils opposes that of the main generator coils and when the lamps are turned on this requires a higher generator output to produce the same magnetic pull on the floating plungers of these two coils. This provides that the batteries will be charged somewhat at night, yet during the day time when all of the generator output must go into the batteries, the rate will not be excessively high.

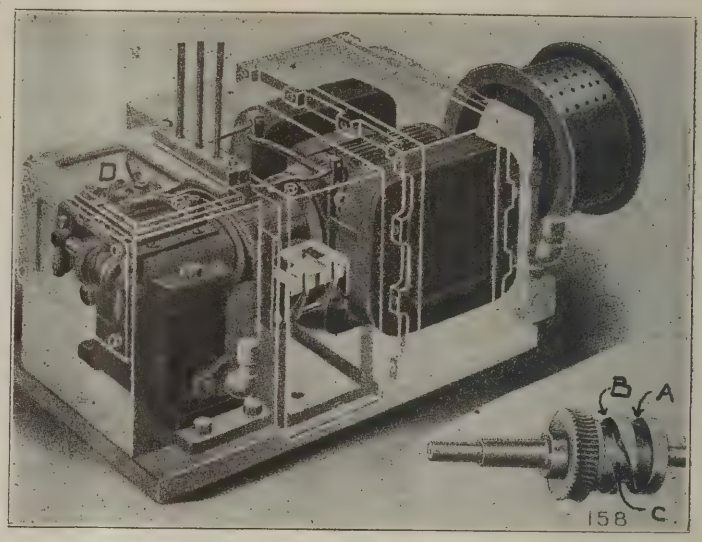


Fig. 90. Type A. Generator.

Lamp Voltage Regulator.

The lamp voltage of this regulator is maintained constant irrespective of battery voltage, number of lamps in use, the speed of the train or any other variable. A pair of solenoids shown on the left hand side of Fig. 89 are wound with fine wire and placed in series with a resistance directly across the lamp circuit. The plunger of this double solenoid engages a double cam follower which is operated by the revolving cam shaft in the same manner as explained above for the machine regulator. If the voltage is too high the plunger will be drawn up and the lower follower come in contact with the revolving cam. This will cause a small pawl to oscillate rapidly back and forth and engaging one of a pair of ratchet wheels, will drag the contact arm of the lamp resistance around step by step cutting resistance into the lamp circuit. When the voltage falls below normal, the solenoids will drop down and allow the upper follower to come in contact with the cam and this will engage the other ratchet wheel and drag the resistance contact arm back in a reverse di-

rection, cutting out resistance from the lamp circuit and bringing the lamp voltage back to normal.

The regulator may be set to operate at any certain voltage by adjusting the tension on a small spiral spring instead of exerting a direct pull as is found in most devices. This spring adjustment is made by means of a small ratchet wheel on the end of the shaft.

Automatic Switch.

The automatic switch is identical with that explained in connection with type "A" equipment in our November 1912 lesson No. 10, except for detail in regard to its mounting.

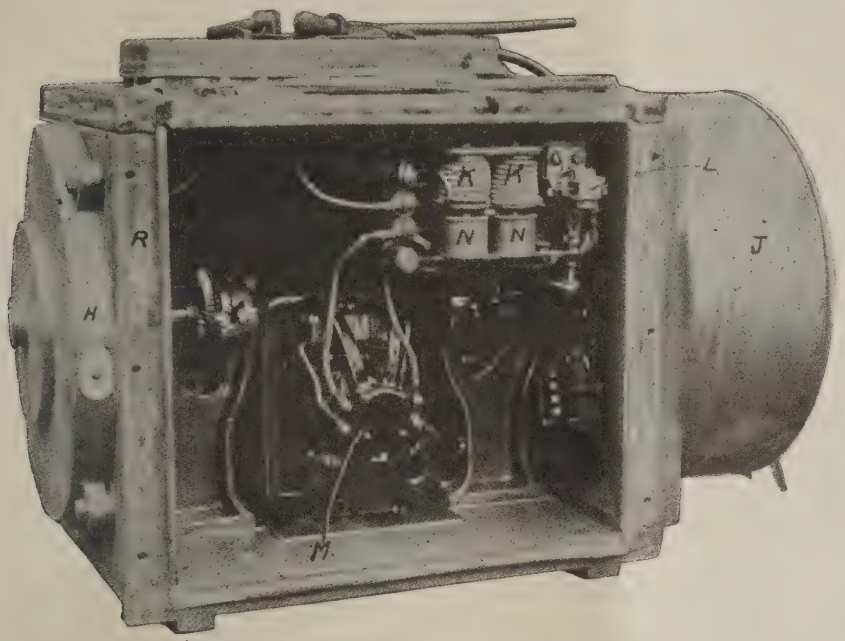


Fig. 91. View from Opposite Side of Regulator Shown in Fig. 89.

Generator.

With earlier equipments, the original type "A" generator was employed as described in the above lesson.

Reducing Charge Feature.

As an auxiliary appliance to the Kennedy regulator there has been developed a reducing charge switch which may be set to close on any predetermined voltage by means of an adjusting spring. When this voltage switch closes, it will allow current to flow through a pair of auxiliary shunt coils of fine wire which are placed on the two machine regulator solenoids. These auxiliary coils are wound so that their magnetism is in the same direction as that generated by the main series winding. This auxiliary magnetism will then replace a certain amount of the magnetism developed by the charging series coils and so reduce the amount of charging current flowing through them. It requires a certain amount of magnetism to provide the magnetic pull equal to the pull of the adjustable spring, and where a certain amount of this magnetism is supplied by the auxiliary coils the amount required from the series charging coils is correspondingly reduced.

Attention should be called to the fact that there is a small spring contact provided at the end of the lamp rheostat sweep and this provides that the operating solenoid of the charge reducing switch cannot be energized until all the lamp resistance has been inserted. This is the normal position of the rheostat when no lamps are burning. As soon as any lamps are turned on the lamp resistance sweep moves away from this spring contact and opens the circuit through the charge reducing switch, and this switch in turn opens the circuit through the auxiliary shunt coils, thus allowing dynamo to put out its normal current whenever lamps are turned on.

When testing out an equipment on the road which has this charge reducing feature, to see what the generator output is, a few lamps should be turned on to make sure that the auxiliary coils are cut out and the generator delivering its normal output.

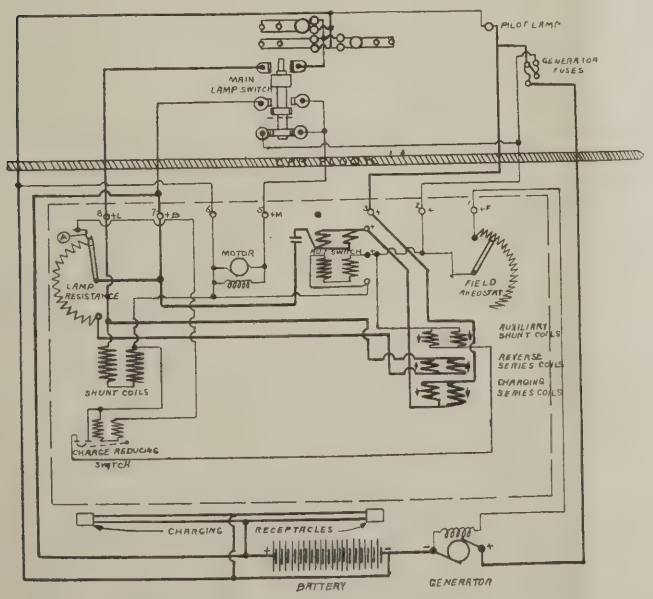


Fig. 92. Wiring Diagram of Kennedy Regulator with Charge Reducing Feature.

Head-End Systems

GENERAL ELECTRIC AUTOMATIC HEAD-END SYSTEM.

In order that the operation of the entire head-end turbo generator equipment might become automatic in its operation the General Electric Company, about six years ago, developed the G. E. automatic head-end equipment as described in this issue. Several equipments were installed on certain roads and were in operation for several years, but have all been subsequently taken off. The equipment, however, contains many points of interest to the car lighting man, and these lessons would not be complete without a full description of it.

Generator Equipment.

The generator is mounted either on the locomotive or in the baggage car and the only attention required from the baggage man or the locomotive fireman is to simply open or close the steam valve. When the voltage of the generator comes up to normal value, it will energize the lifting coil and a reverse current relay, which is very similar both in its construction and operation to the single solenoid type automatic switch as used in axle generator equipment. There is both a shunt and a series winding on this relay. The shunt coil lifts its plunger with lower switch contact adjusted and after the switch is closed the generator current flowing from the generator to the line increases the magnetic pull of the shunt coil and holds the switch firmly in place. When the equipment is shut down in the morning, at the end of the run or at engine changes, or when the generator

voltage falls slightly below the floating voltage of the storage batteries there will be a reverse current flow from the batteries into the generator, tending to run the generator as a motor. This reverse current flowing through the series coil of the relay will generate magnetism which will oppose the magnetism of the shunt coil and when the reverse current becomes heavy enough will neutralize the shunt coil magnetism and the relay will then drop open, disconnecting the generator from the line. After the automatic switch is closed, the generator voltage becomes operative. This is at the left hand side of the wiring diagram, Fig. 93. This diagram represents the wiring circuits of three cars and the locomotive or baggage car as indicated.

The generator voltage regulator consists of two coils placed in series with each other and connected through a resistance across the generator terminals. The main coil is wound with fine wire over an iron core and the floating coil is mounted on a movable contact arm to which is attached an adjustable spring. When a current flows through these two coils the magnetic field generated, will cause an attraction between them, the higher the voltage the more current flowing through the two coils and the stronger is the pull of attraction. When the generator is operating at normal voltage, the pull of the main coil on the floating coil will just balance the pull of the adjustable spring. But when the voltage goes too high, however, the attraction between the two coils will increase and the floating coil carrying contact will be raised, opening the contact slightly.

It will be noted from the wiring diagram, Fig. 93, that the generator field circuit includes two fixed sections of resistance. The lower section is divided into two parts with the field current feeding into both ends and leaving from the center. The upper half of this resistance is fixed and the field current flowing by this path will be constant; the lower half of this resistance, however, is in series with the floating contact and current voltage, and opening this contact will cause the field current and generator voltage to decrease.

In maintaining the generator voltage at proper value, this contact is open and closed more or less rapidly, the ratio of time closed to time open depending upon the amount of regulation necessary. As explained in our

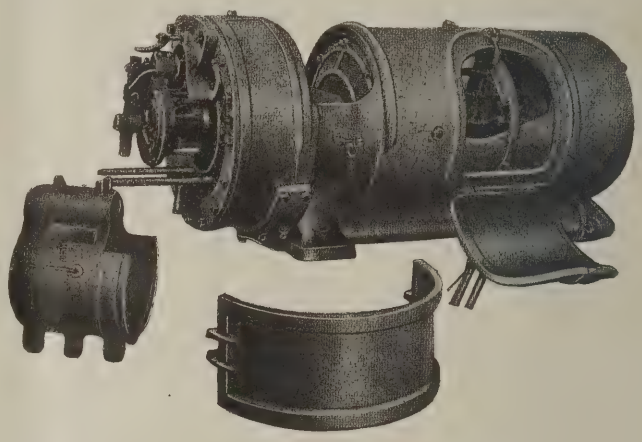


Fig. 94. 15 k.w. Turbine Set, Locomotive Type, Open for Inspection.

lesson No. 12, January, 1913, the generator field builds up slowly after the circuit is closed and similarly when the circuit is open, the field does not at once drop off to zero but decreases gradually. This is due to the inertia effect of magnetism and with large fields this building up and cutting down may require as much as a second or so of time; so when this contact is closed and opened at a certain rate, the generator field current will be maintained at an average value required to furnish the proper voltage.

Car Equipment.

There are two different types of car equipment shown

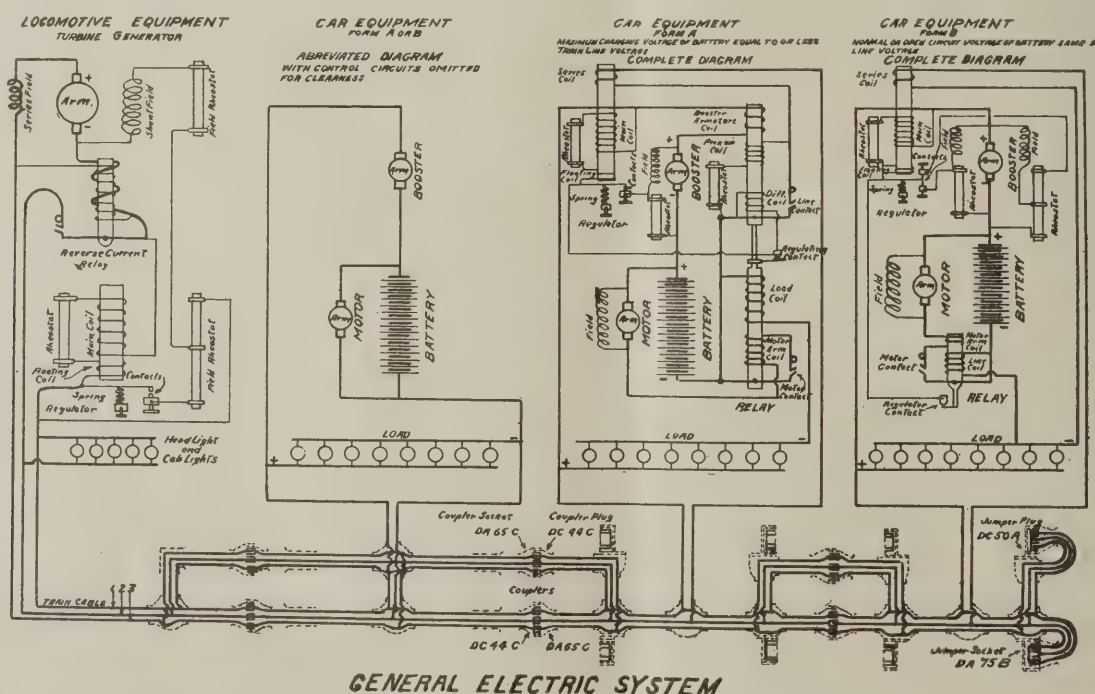


Fig. 93. Wiring Diagram of Automatic Head-end System.

can only feed from the lower half when this contact is closed. There is then two paths for the generator field current here, and the total field current is the sum of the two. The closing of these contacts will allow more current to feed into the generator field and so increase its

in the accompanying diagram. "Form A" has a smaller number of storage battery cells than ordinarily so that the maximum charging voltage of the battery will be about equal to or slightly less than the train line voltage. In this case, the booster boosts the battery voltage on

discharge and bucks (but only to a slight degree) on charge. The other equipment "Form B," shown in the last car on the right of Fig. 94, the battery has the full number of cells and the normal or open circuit voltage of the battery is about the same as the line voltage. The booster in the latter case boosts the battery voltage on discharge and also boosts the line voltage in charging batteries. The second car from the left end of the wiring diagram is an abbreviated wiring diagram with all control circuits omitted for the sake of clearness. A booster set is located under each car and this consists of a motor armature, and the booster armature which are mounted on the same shaft. The motor is connected directly across the battery terminals and is operating whenever the batteries are charging or when any lamps are turned on.

Referring to the wiring diagram, "Form A," the second from the right of Fig. 94, it will be seen that there is a regulator for controlling the operation of the booster very similar to that explained above for controlling the

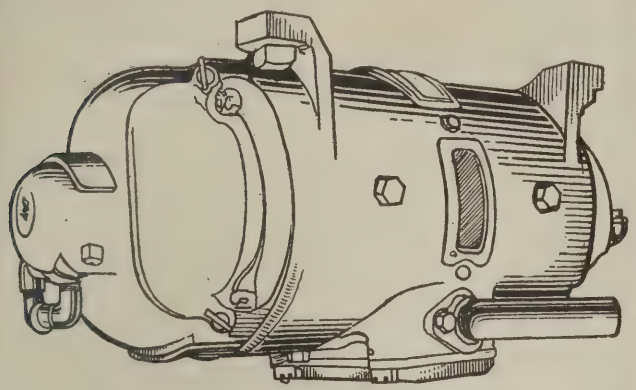


Fig. 95. Sketch of Booster.

generator voltage. However, the contacts do not shunt the portion of the field rheostat as in the case of the generator regulator, but open the field completely. This regulator is located in a cast iron box underneath the car, and a special relay is enclosed in the same box. This automatically starts the booster set when the generator is connected on the line and shuts it down when regulation is no longer required. When the turbine is shut down or this particular car is disconnected from the train line, the lamps are fed from the battery as explained above. In this type regulator there are a fewer number of cells than ordinarily used, but the booster raises the battery voltage on discharge up to a normal line voltage.

When the turbine is started it energizes the pickup coil which is connected through a resistance right across the main line switch of the relay. This raises the relay plunger, closing both the motor contact and the main line contact, and at the same time automatically short-circuits itself. When the relay switch is closed the motor will start and drive the booster armature, and there will also be a fairly heavy current flow for an instant through the battery because there is no opposing voltage in the "booster" (or "bucker") armature. It will be noticed that the relay has mounted on it five windings; the pick-up coil, the armature coil, differential coil, load coil and the motor armature coil. On discharge the magnetism of all the coils acts in the same direction, but on charge the booster armature coil which carries all the battery current, reverses, and opposes the other coils. By means of the regulating contact of the relay, which is in series with the current flowing through the coils of the regulator, the relay controls the operation of the booster. When the generator is connected to the line, the voltage is slightly higher than when the lamps are fed from the battery, so the floating coil of the regulator is pulled up and the contact completely open. This cuts the booster field current down to a very low value, in fact, the only current flowing through this field is that generated by its own potential. This allows the battery to charge freely.

It should be noted, however, that the total bucker armature current passes through the relay so that if the charging current becomes excessive this will operate the regulating contact of the relay and by boosting the voltage of the booster, (which on discharge in the form "A" equipment is a bucker) maintains the charging current at normal value. If there is a large number of lamps in use on the car, this current passing through the lower coil will energize the relay and reduce the maximum battery charging current possible. The coils of the relay are so proportioned that when no lamps are burning there will be a slight taper given to the battery charge until the gasing point is reached, when it will taper off more rapidly to a low value. If the steam pressure is reduced or the total load becomes greater than the generator can handle, the line voltage will drop slightly and allow the car regulators to come into action. This will furnish a strong field current to the booster and the voltage of the booster will then add to that of the batteries in discharging into the line and helping out the generator.

It would seem that this last point, however, might become a rather serious objection, for if the generator voltage relay happens to be set slightly higher than the setting of the relay in any car in the train, there would be a constant discharge of the battery on that car as explained.

With the "Form B" regulator, the full number of batteries are supplied and the normal or floating battery voltage is about equal to the line voltage. It should be noted from the wiring diagram at the right hand side of Figure 94 that there are two field windings applied to the booster. One operates when the battery is being charged, and the other operates when it is being discharged. The operation of these two fields is controlled by a double set of contacts on the regulator contact arm, one above and one below as shown. These field coils are mounted on the same pole pieces but are wound in the opposite direction and they are never both in operation at the same time.

On charge the floating coil of the regulator is lifted up and closes the upper contact, thus energising the right hand field of the booster. This causes the booster armature to add its voltage to the voltage of the generator in charging the battery.

On discharge when the turbine is shut down the voltage falls slightly and the floating coil of the regulator with the contact arm falls, closing the lower contact. This puts the bucker field shown on the left hand side of the booster armature into operation and the voltage generated in the bucker armature is then of the polarity as shown in the diagram and boosts the battery voltage slightly so as to furnish normal voltage to the lamps.

Practical Stunts

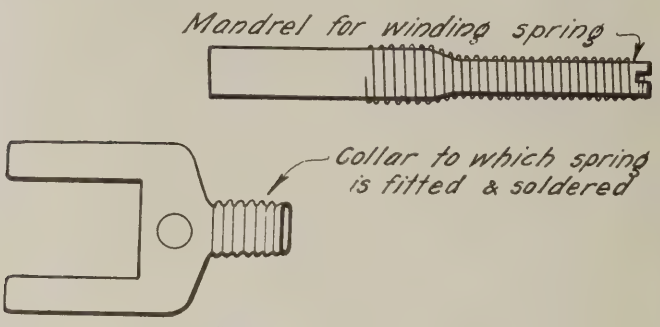
(We pay a dollar apiece for each practical stunt published. Send in your ideas.)

Preventing Breakage of Dynamo Leads.

In order to prevent the flexible leads from the axle dynamo breaking due to the vibration in service, a spiral spring attachment has been applied on many of our cars. This is the same as is employed in very

many other electrical devices, such as flat irons, etc., which have a flexible lead attached to a moving body. A spiral spring made of No. 18 brass spring wire is wound on a tapered mandrel as shown in the accompanying diagram. The base of the spring is wound larger so as to fit the collar of the flexible lead terminal, to which it is securely soldered.

The mandrel should be designed to fit the chuck of a lathe and should have the small end slotted to receive the wire before winding. The spring is then wound to approximately 2½ inches in length.



Dynamo Lead Support.

The smaller section of the mandril is made so that the spring when finished will just slip over the insulation of the wire. A spring then is applied to each end of the wire and the lead terminals soldered to the wire and the wire spring to each lead terminal.

The repair of flexible leads is assigned to me and after having leads fitted with these springs in general use for over 4 months I have not had one returned in bad order.

(If the contributor of this good stunt will advise us of his name and address, check will be forwarded.)

Train Lines Installed Wrong.

Occasionally we find axle lighted cars in which the train lines have been reversed when the car was originally wired. This trouble will not be apparent until the car is connected into a headend train and train connectors put up.

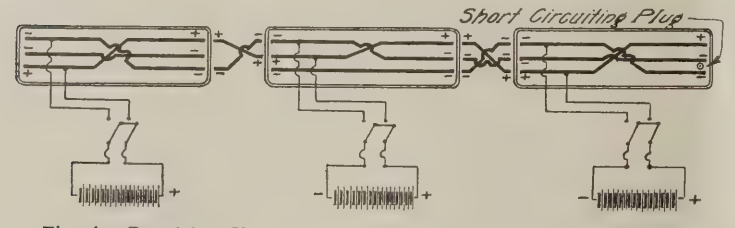
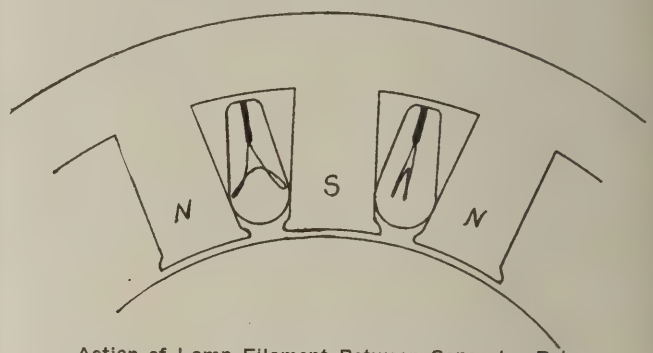


Fig. 1. Repairing Trouble of Train Lines Installed Wrong.

The center car of Fig. 1 is wired wrong as shown, and when this is connected up with other cars it will cause a short circuit. To remedy this trouble on the road where only temporary repairs can be made, open the short circuiting plug on the female receptacle of last car (or loop switch) and remove the male connector from the forward end of the car that is wired wrong. By removing the short circuiting plug at the rear of the train it makes the generator negative train line dead and the positive and negative battery and lamp mains can then be identified with a volt meter at the female receptable on the forward end of the car wired wrong. Remove the center cable from this connector and place the two side cables to correspond with positive and negative connections in the female receptacle of the center car as shown in the diagram. If the short circuiting plug on the car ahead of the car in trouble and the short circuiting plug or loop switch at the rear of the last car of the train are plugged in, the train line will then be O. K. and the lights will burn properly. We have then an ordinary three wire system of all cars ahead of the car in trouble and a similar three wire system for all cars to the rear of and including the car in trouble with a two wire connection between the two systems. The lamp voltage of the rear cars, however, will be a trifle lower than that of the cars ahead. Geo. C. Elbreder.



Action of Lamp Filament Between Generator Poles.

Testing Polarity of Field Coils.

The *Electrical World* publishes a note by Mr. E. R. Shepard stating that in testing the polarity of the poles of an alternator an ordinary carbon-filament lamp carrying a direct current was found to give very striking and definite results. By placing the lamp in the region of the leakage flux between adjacent pole tips the two loops of the filament will separate widely or draw close together, depending on the direction of the flux. By progressing around the fields with a lamp in this manner a reversed pole or a dead pole can be instantly detected. The behavior of the lamp is indicated in the accompanying illustration.

Connection of Battery to Train Line Reversed.

It is sometimes found when an axle lighted car is connected into a train line that the battery fuse is at once blown and upon investigation it is found that the battery connections to the train line have been reversed. The train line of that car itself, however, may be O. K. but on connecting it up with any car wired according to A. R. E. E. standard with battery positive to the right on female connector, a short circuit will occur. This can be remedied by opening the train line fuses and crossing them as shown in the diagram of Fig. 2. Geo. C. Elbreder.

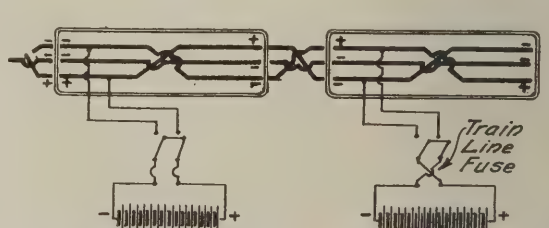


Fig. 2. Rectifying Reversed Battery Connection to Train Line.

Car Lighting Generator Under Water.

The Safety Car Heating & Lighting Co. report that during the severe flood in the middle west recently numerous generators were under water for two days. When upon being put into service after the flood waters had receded they were not damaged in the slightest. Their experience with the flood has in no way interfered with their present operation and apparently will have no effect on their further service.

TRAIN LIGHTING ASSOCIATION OF ST. LOUIS.

The reception and ball given by the Pioneer Electric Train Lighting Association of St. Louis at the Compton Hall Academy April 12th was very successful. The car lighting club assembly room located below the academy on the second floor was neatly decorated and a large "Welcome" shield was mounted over the doorway. Mrs. E. E. Schuddig, of St. Louis, a local soprano singer of note, offered a few selections which were accompanied by piano and violin, and the "Majestic Four," H. F. Mohler, J. C. McConnell, A. H. Dessau, and R. S. Stark, were in the limelight. Mr. Mitchel Wray, the well-known St. Louis classic ragtime player, entertained those on the second floor between dances with a few of his late ragtime selections which were highly appreciated. Soft drinks only were served and smoking was allowed only on the second floor. The reception started at 8 p. m. and the orchestra played the Home Sweet Home at 1 a. m.

The committee on arrangements deserve credit for a great deal of the pleasure of the evening, and I wish to thank our advertisers for their support to make this affair a success.

G. C. Elbreder,
Secretary.

Floor Committee.
H. F. Pfeffer, Mo. Pac. Ry.
G. C. Elbreder, C. B. & Q. Ry.
I. Alstatt, St. L. & S. R. Ry.
H. Mayer, Pullman Co.
C. Ross, Penn. Ry.

Door Committee.
T. C. Birch, Pullman Co.
E. A. Corbett, Pullman Co.

Arrangement Committee.
C. A. Franck, Chairman, Big Four Ry.
C. Gelan, Oliver Elec. & Mfg. Co.
H. P. Reed, Pullman Co.
L. Altstatt, Ill. Cent. Ry.
J. Ottey, Mo. Pac. Ry.

ST. LOUIS QUESTION BOX.

Editor's Note:—The following questions and answers were presented at a recent meeting of the Pioneer Electric Train Lighting Association of St. Louis.

1. Why will a generator with one field coil reversed motor O. K. in the yards, yet will not pick up on the road?

Answer. A generator which has one field coil reversed has about the same action as one which has one field short circuited or when there is a heavy field resistance in circuit. When the machine is motored it will have a tendency to race because of the fact that the total field strength of the generator is only half normal since the magnetism of the reversed coil merely neutralizes the magnetism of the coil opposite and two of the four fields are cut out. We know a motor goes faster as the field is reduced and it is the same way with the car lighting generator having one field coil reversed.

The machine will generate on the road but will not cut in until the train speed is about twice the normal cutting in speed. The high armature speed will then compensate for the loss in field strength. The only effect of a reversed field coil is to weaken the field of the generator.

Q. Some roads consider 28 volts a light failure, while others 26 volts a light failure where mazda lamps are used; other roads don't seem to consider a failure at all. What is the proper basis for determining when failure has occurred?

A. The general impression which one obtains from a car with low battery will usually be sufficient to determine whether there has been a failure or not. The voltage reading, however, should be taken.

Q. What will cause carbons on Bliss type K relays to go to pieces when all connections are right?

A. This is usually caused by the top carbon contact being loosely adjusted so as to allow a small space between the top carbon and the top carbon disc. This will cause the relay to rattle and there will be some arcing between all of the discs which will rapidly deteriorate them.

Q. How will a short circuited cell affect a set of batteries?

A. The first indication is a drop in voltage of approximately 2 volts below that of the full set of batteries. This, however, will depend upon the nature of the short circuit and where only a slight short circuit occurs the voltage may not be seriously affected. Even a slight short circuit, however, will seriously discharge that particular cell and if not removed will cause the plates to sulphate.

Q. If a set of batteries is totally discharged, is the axle device capable of charging them in a reverse direction?

A. In order to charge a battery in a wrong direction after it has been completely discharged, the permanent magnetism of the generator fields or the connections of the exciting lamp circuit would have to be reversed. The machine will deliver proper polarity regardless of the polarity of the battery. Certain cases of trouble have developed, however, caused by grounds in the generator which reversed the polarity of the generator but these cases are rare.

Q. What is the function of the shunt contact of a Bliss Automatic Switch?

A. This contact inserts a fixed resistance in the auto switch lifting coil when the switch closes. When the switch opens this spring contact short circuits the resistance. The advantage of this is that it reduces the heating effect of the shunt coil when the machine is operating and at the same time requires less reverse current through the series coil of the switch to neutralize the shunt coil magnetism and open the switch.

ELECTRICITY FOR WASHING BOX CARS.

Every day sees a new application of electricity in railroad operation for improving service, lowering operating costs and for greater convenience and comfort of the traveling public.

One of the electric railways of the West is using to very good purpose an electrical machine for washing box cars. The washing apparatus consists of two large cylindrical brushes mounted vertically on each side of a track and driven by a small electric motor. The brushes are piped with water from the shop mains and the washing process consists in simply running the car or train of cars on the track equipped with the revolving washers. The cars can in this way be cleaned very rapidly and with exceedingly low cost. Possibly a modification of this plan might be used to some advantage in passenger coach yards.

GREAT NORTHERN TO ELECTRIFY.

A rumor is current to the effect that the Great Northern Railroad will electrify its road from Spokane to Seattle. About half of this section is through the Cascade mountain country where grades are severe. Power for operating the electrified section will be obtained from large hydro electric developments on the Wenatchee River and the Columbia River. At the point where the road crosses the Columbia over 100,000 h. p. is available.

The Cascade tunnel, which is already electrified, is on this section, and without doubt the satisfactory and economical service experienced in this first electrification has been a potent element in considering the electrification of the entire division.

Care and Operation of Ball Bearing Axle Generators

W. L. BATT

With the large number of axle generators which are being put into service mounted on ball bearings, there are naturally many questions which arise concerning the care and operation of those bearings in daily service. It is quite natural that the electrician who has been caring for the ordinary sleeve bearings and who has had no experience with ball bearings in any other service, may ask how he ought to take care of those bearings in order to get the best results. The purpose of this letter is to mention a number of points which have come to the writer's attention in connection with the use of ball bearings on axle generators and to discuss briefly each of those.

The first of those questions is "Why do ball bearings need to be lubricated? If they roll, as it is claimed they do, where is the necessity for a lubricant whose function is ordinarily to reduce sliding friction?"

The function of lubricant in connection with ball bearings is twofold; first, to actually protect the bearings against the destructive action of moisture and air and against the entrance of grit and foreign material from the outside into the housing; and second, to reduce the small amount of friction which exists in a ball bearing.

Theoretically, a ball in the ball bearing truly rolls. Practically, due to deformation of the material, there is a very material area of contact between the ball and the race upon which it rolls and between the ball and the retainer which is used in the bearing. At the point of contact between the ball and its path, there is a substantial area of contact. At the extremities of this area there is a small amount of sliding, and the presence of a lubricant is necessary to relieve this. At the point of contact between the ball and the separator there is a rubbing action, since the ball bears against the separator. There is a certain amount of pressure at this point, due to deflection of the races and a compression of the balls. Of course, the total amount of all of this sliding action is small, as evidenced by the fact that the total co-efficient of friction of the correctly made ball bearing is only about 1/10 of 1 per cent as contrasted with many times that in the plain bearing and the need for lubrication correspondingly small. Therefore the protective function of the lubricant should be given first importance.

If the housing be empty, then there is opportunity for moisture and grit to enter and to be carried directly into the bearing. If the housing be more or less filled with grease, that will have a tendency to shield the bearing from such outside detrimental influence. Nor must that be construed to mean that the ball bearing is such a fine piece of mechanism that it must be nursed in order to last. In a plain bearing, due to the large amount of lubricant which is constantly added, there is a flushing tendency in the housing which carries, off to a considerable extent, foreign matter which has worked in. But in the ball bearing housing, where grease is put in and the housing is given absolutely no atention for many months, it is important that as much care as possible be taken to keep the housing clean.

Because the grease is only infrequently changed, it follows that it must not deteriorate with age to any extent. The grease is subject to considerable extremes of temperature, and to an intense pounding action, as the bearing constantly rotates through it and the result is that every grease cannot satisfactorily meet the test for ball bearing lubrication.

We have found that a grease wants to be smooth in body and fairly thick to give the best results. Of course it must not contain nor develop acid or alkali which would attack the finely polished surface of the bearing.

Lubricant should be added just frequently enough to replace that which works out of the housing or evaporates. This amount will be one thing with one generator and one type of grease, and quite different with a different generator and a different type of grease. When ball bearings were first tried on axle generators, they were lubricated every two weeks. It was quickly found that the grease was being forced over into the machine, and the lubricating periods were successively lengthened to one month, two months, and three months. Since the bearing was entirely enclosed in the housing it was even then impossible to tell how much grease was in the housing and just how much ought to be added, and various operators adopted a sort of formula as to the number of turns of a standard grease gun which should be given at each lubrication. This was satisfactory if rigidly lived up to, but with the grease gun entirely full of grease, there was just as much tendency to overcharge the housing as there is to set up a generator belt too tight (in order to be on the safe side as it is so explained).

Our experience, in general, has been that about two to three pounds of grease per generator per year is necessary. It apparently is most satisfactory if the machine is lubricated thoroughly every six months, and in the meantime is given no further attention. At those lubricating periods, it would seem best to entirely remove the armature from the machine; to clean the bearings out in kerosene and to replace them with fresh grease. A machine whose bearings operate free from all attention for six months at a time, deserves that small amount of care twice a year, and we believe no operator will have any objection to giving it. When fresh grease is put in the housings then, it should be filled about two-thirds full. The actual amount of grease to be added will depend on the type of machine.

The question has frequently been asked as to how long a ball bearing will last, if properly taken care of. It is impossible to answer that question absolutely, because no generators have been running in this country for the full life of the bearings.

The first bearings installed of the No. 7412 size, about two and a quarter years ago, are running today in quite as good condition as when they were installed. They show only a few ten thousandths freedom and the inspection of the ball grooves and the balls shows those to be in perfect condition. Hess-Bright ball bearings installed in mining locomotive motors and on street railway journals and motors almost five years ago are still running today in good condition. They have so perfectly met the terrific duty on mining locomotives as to be practically standard in that field. It is the writer's opinion that we may certainly expect from six to ten years' life from axle generator ball

bearings of the proper kind. Of course there are many kinds of ball bearings, just as of anything else. This statement can only be taken to apply to Hess-Bright Bearings, which have the largest possible ball diameter, with heavy raceways, deep ball grooves and solid manganese bronze separators.

The question has been asked as to how much care is necessary in getting the housings in absolutely true and straight, or as to what would happen to the ball bearing in case the shaft should be bent due to extreme belt load. As a matter of fact, Hess-Bright ball bearings will permit a great deal more shaft deflection than was ever possible with a plain bearing. The grooves in which the balls roll are ground somewhat larger than the balls themselves and this permits a certain tilting action without any sacrifice of the carrying capacity of the ball grooves. About 1/16 of an inch to the foot may be safely had without in any way affecting the bearing. As a matter of fact, it is not possible to obtain even this much before the shaft shall rub on the housing lip and create trouble. Such conditions, however, are so very rare, that they need not be considered.

Some have asked how they were to know if the ball bearing was all right since much of it could not be seen. The answer to this is that if trouble begins in the ball bearing it will quickly manifest itself. If, as extreme case for instance, a ball should break, this would produce pitting of the race grooves and rough running, and consequently heat. The generator would therefore be turned in as hot. The bearing could run for some time, however, before this became noticeable, and it would not be possible for the armatures to drop on the pole pieces because of the heavy manganese bronze retainer in a Hess-Bright bearing, which acts substantially as a second plain bearing in case the balls should be so badly damaged as to not carry the load. There is a smaller amount of space between the retainer and the raceway than there is in the air gap. From an experience of many years in mining and street railway work, it is reasonably certain that a ball bearing on an axle generator would last several days after some damage had been done to it, and that it would simply ultimately be turned in as hot. There has never in five years of street railway and mining locomotive experience been a case of an armature on ball bearings on the pole pieces.

The number of generators at present out on Hess-Bright ball bearings has considerably passed the 1,000 mark, and the maintenance costs on those are so much less than the cost on plain bearing machines as to be entirely negligible. It is very evident that the ball bearing has come to stay in axle generator service.

MORE TELEPHONES ON THE CHESAPEAKE & OHIO.

In continuance of their policy of increasing the telephone equipment on their lines, the Chesapeake & Ohio Railroad officials have placed an order with the Western Electric Company for the apparatus necessary to equip another division of road with telephone train dispatching facilities.

The section of the road to be equipped is familiarly known as the Big Sandy Division and operates in the eastern part of Kentucky in the Cumberland Mountain region. The telephone train dispatching circuit covers the entire section, a distance of approximately 135 miles, and extends from Ashland, Kentucky, to Elkhorn City, Kentucky. The dispatcher will be located at Ashland.

Western Electric No. 102 type selector sets arranged for local battery use will be used at way stations for receiving the dispatcher's signals. These selector sets contain the widely used No. 50 type selector. Twenty-eight way stations will be equipped with selective signaling and talking apparatus.

ANNUAL MEETING OF THE ASSOCIATION OF RY. TELEGRAPH SUPTS.

The annual meeting of the Railway Telegraph Superintendents' Association will be held at St. Louis, May 20-23.

Some valuable papers will be presented and it is expected that a large number of railroad men from all over the country will be present.

The following is a list of the papers to be presented:

"Inductive Disturbances as Effecting Telephone and Telegraph Lines," by P. F. Howe, Gen. Plant Dept. of Western Union Telegraph Co.

"Protection Against Lighting and High Voltage Currents for Telegraph and Telephone Equipment." Mr. H. Clapp, Supt. Tel., Northern Pacific Railway.

"Full Use of Wires. H. D. Teed, Supt. Tel., Frisco.

"Organization for Wire Chiefs and Telegraph Inspectors." J. B. Shelden, Supt. Tel., Union Pacific R. R.

"Some Phases of Organization for Maintenance of Lines." W. C. Allen, Div. Plant Supr., Western Union Telegraph Co.

A NEW GENERAL UTILITY BATTERY.

The Western Electric Company has recently placed upon the market a new dry battery to be known as the "Red Label Blue Bell Battery." It is encased in a bright red carton, and is designed for intermittent service requiring high efficiency and rapid recuperation. This new battery is a result of careful development work extending over a long period. The service for which the battery is intended made it necessary to investigate with great thoroughness every possible use to which it might be put, so that it could truly be called a general utility battery. The design having been completed and experimental batteries manufactured under the new specifications, exhaustive life tests were made, duplicating service conditions, and the battery "proven in" to the satisfaction of all those concerned in its development from every point of view—manufacturing, engineering and sales.

TELEPHONE EQUIPMENT FOR ERIE RAILROAD COMPANY'S PRIVATE CARS.

The private car of a railroad official is an exceedingly busy place. The official who travels in one occupies most of the time in transacting business. This necessitates car equipment as modern as the equipment in his regular office.

The Erie Railroad Company is equipping its private cars with intercommunicating telephone systems which are similar in effect to those used in business offices and factories. President Underwood's car, No. 999, was the first one to be equipped. It has a system of six stations interconnecting the staterooms, observation room, stenographer's desk, and the kitchen. A conversation may be carried on between any two of the telephones, and orders transmitted, without either person leaving his place.

The apparatus used was furnished and installed by

the Western Electric Company. The telephones are hand sets, each equipped with a cord and plug. Jack plates are mounted on the car wall, each having a push button and jack into which the plug of the hand telephone is inserted. When not in use the plugs are withdrawn and the hand sets are stored away. The different stations are called by means of a buzzer system. The call buttons are arranged on a dial plate and the system is so wired that only the buzzer at the telephone wanted is rung. The ordinary wall or desk telephones would not give satisfactory service on moving trains. They would be satisfactory as long as the train was at a standstill, but as soon as in motion the vibration of the wheels upon the rails would be carried to the transmitter and the resulting noises completely drown the telephone conversation. The use of hand sets obviates this difficulty as the body acts as a shock-absorber.

The telephone system is also arranged for making connections with an outside telephone line so that local or long distance calls may be had from the car. The signaling current for calling the telephone exchanges is obtained from an interrupter operated from batteries.

Other private cars on the Erie system will be equipped as rapidly as it is possible for them to be called in from active service long enough to complete the installation work. These intercommunicating telephones make complete the convenience of the private car.

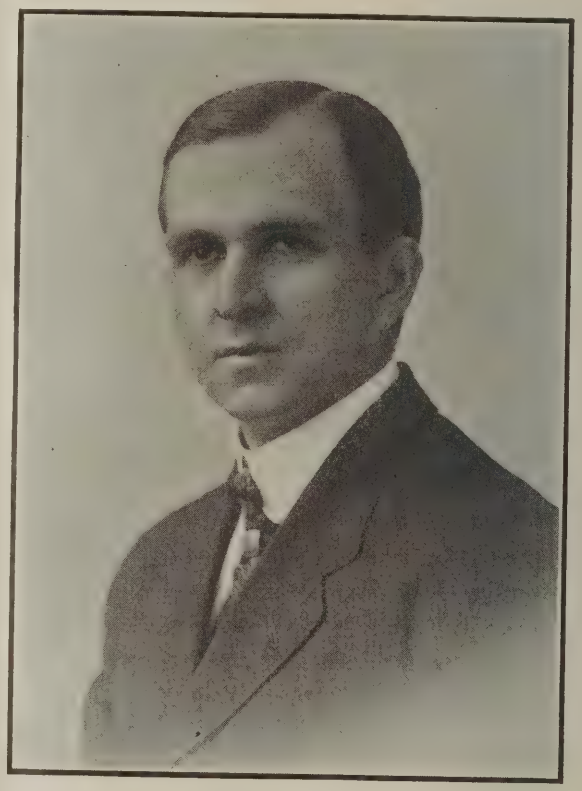
General News and Personal Mention

ARTHUR J. SWEET.

The many friends that Mr. Arthur J. Sweet has made as Commercial Engineer of the Holophane Works of the General Electric Company, will be sorry to learn that he has tendered his resignation to that company. He is to become a member of the firm of Vaughn and Meyer, Consulting Engineers, Milwaukee, Wis., which will be hereafter known as Vaughn, Meyer and Sweet. We congratulate him on this, but cannot forget the loss of one of our best illumination men in the railway field, for although he will continue his activity in car lighting work for a few months, the duties imposed by his new work will hardly permit of the continuation of his energetic and valuable work of the past two years. Mr. Sweet has been prominently identified during the last five years with research and commercial development work in the field of illuminating engineering. During the past two years he has given his especial attention to the subject of railway lighting in its many phases, and last summer served as consulting engineer in direct charge of the extensive research work on postal car lighting which was conducted at Washington, D. C., under the auspices of the Baltimore & Ohio R. R.

The association of Mr. Sweet in the firm of Vaughn & Meyer has come primarily as a result of the firm's growing practice in the fields of efficiency engineering and industrial appraisal work, as additional to its well-established practice in steam and electrical engineering. Mr. Sweet will give his chief attention to handling the firm's extensive illuminating engineering practice and of directing the details of the office work, thus relieving the other members of the firm for their more extensive practice in the fields above mentioned. Mr. Sweet's energy and conscientiousness in his work have won him many friends whose good will and support will follow him in his new work.

Mr. Sweet has been widely known among railway engineers for his valuable and highly specialized study yet very practical study of problems in illumination peculiar to railway service, particularly the problem of railway car lighting in all its many phases. It is not putting the matter too strongly to say that Mr. Sweet has done more than any single individual to raise the standard of railway car lighting, and to point out the direction which still further future improvements in this field should take. Among illuminating engineers, Mr. Sweet is best known for his research work. His writings on the subject of illumination have won for themselves a wide audience. Among these writings may be mentioned, "The Influence of Illumination Conditions Upon Eye-Strain," and "Reflecting Media," both of these papers being based upon addresses given before various sections of the American Institute of Electrical Engineers, and later were published in the *Railway Electrical Engineer*.



Arthur J. Sweet.

MR. J. G. VAN WINKLE LEAVES SAFETY COMPANY.

Mr. J. G. Van Winkle, who for the past two years has been manager of the Chicago office of the Safety Car Heating and Lighting Company, has just been appointed Vice-President of the Vandalia Coal Company, with headquarters at Terre Haute, Indiana.

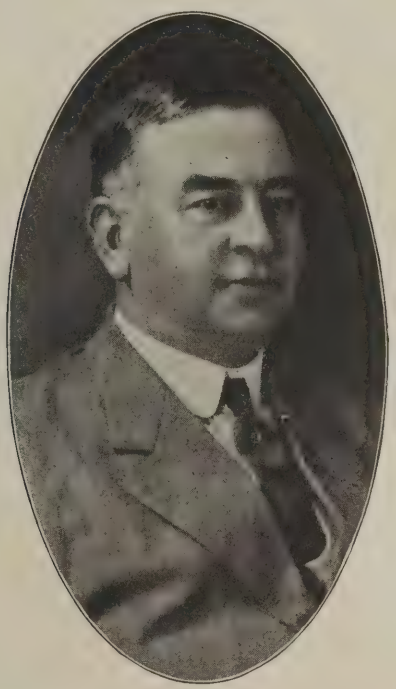
Mr. Van Winkle has been active in car lighting matters and served very efficiently on the executive committee of the Railway Electric Supply Manufacturers' Association. His many friends will be pleased to hear of this big advancement and we all extend our best wishes for continued success in his new work.

COL. JOHN T. DICKINSON.

The older men in the car lighting game will remember Col. John T. Dickinson as one of the pioneers who labored long and industriously before a few railroads were finally induced to put a few experimental car lighting equipments in operation. Col. Dickinson was also very active in Association matters when the Association was first organized, but for the past three years has been engaged in the successful promotion of a splendid hotel and seaside cottage town at Corpus Christi, Texas. This has developed into one of the most delightful watering places in that part of the country, and undoubtedly has a big future.

Col. Dickinson has recently returned to Chicago and accepted a position with the Gould Coupler Company in the sale of their electric car lighting equipment and their other standard railway specialties with headquarters at their Chicago office in the Rookery.

Col. Dickinson is a native of Houston, Texas, and started in railroad service as a boy in the general office of the Houston & Texas Central Railway, now a part



Col. John T. Dickinson.

of the Sunset Central Lines. He afterward attended college in Virginia and graduated in law at the University of Virginia in 1879 at the age of twenty-one. He was Secretary of the State Capitol Board at Austin, Texas, from 1881 to 1888. He was Secretary of the Chicago World's Fair National Commission from 1890 to 1894. From 1894 to 1897 Col. Dickinson was President of the company that built the great Coliseum building near Jackson Blvd. in which Secretary of State Bryan was nominated for President by the Democratic National Committee in 1896 and which building afterwards burned. In 1900 Col. Dickinson became officially connected with the first two companies that largely introduced the axle light system of electric car lighting which is now coming into such general use on railway passenger cars.

OTTO HIESTER JOINS EDISON FORCES.

A. Otto Hiester, who has been manager of the Buffalo office of the United States Light & Heating Company, and previously with the National Battery Company, has joined the sales force of the Edison Storage Battery Company.

NEW GOULD BATTERY INSTRUCTION BOOK.

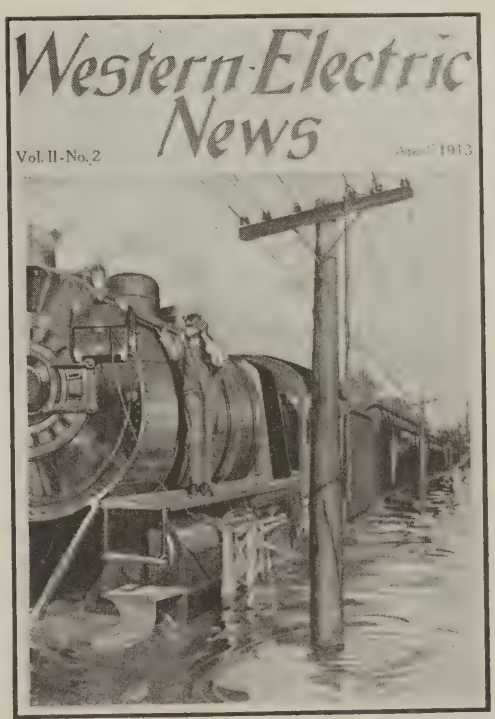
The Gould Storage Battery Company have just issued a new instruction book on the care of their storage batteries. The book describes the various parts of the battery and goes into the detail of battery manufacture to a certain extent.

The various accessories used in connection with batteries such as volt meter with special contact lead, hydrometer, hydrometer syringe, lead burning outfit and cadmium electrode are also described. Detail instructions as to electrolyte, placing the battery in commission, its care and service, treatment of cells in poor condition and battery cleaning are then given. As an appendix to the instruction book there are given some valuable curves showing the characteristics of the Gould battery.

The Gould Storage Battery Company have very courteously placed at our disposal about 700 of these books and they will be furnished to all of the boys taking our special car lighting course as were the instruction books of other battery manufacturers. By all others this book may be had on application to the Gould Storage Battery Company, 341 Fifth Ave., New York, N. Y.

The Telephone in the Flood.

The accompanying illustration which formed the front cover of the Western Electric News for April gives a striking illustration of the great advantage that a train telephone set can be in times of greatest



need. This shows a passenger train in the throes of a surging flood, but the engineer by means of his telephone set gets immediately in touch with the train dispatcher.

THE AMERICAN PULLEY COMPANY'S BANQUET.

The officers of the American Pulley Company were hosts at a banquet held at the Germantown Cricket Club of Philadelphia on April 1. Mr. C. A. Brinley,

The Five Essentials

You Can Tell a "D & W" Fuse At a Glance

They are Different. LOOK FOR →

Four Screws in Each Cap

Safe Indicator
No Exposed Metal

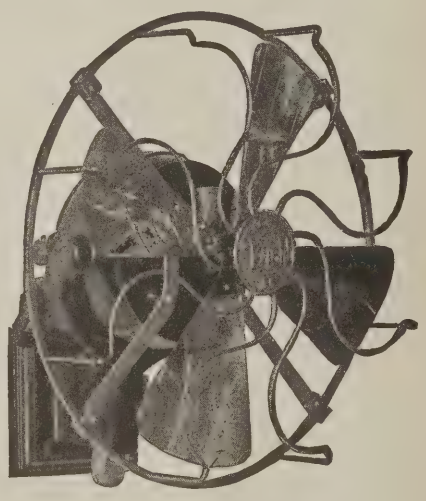
Full Rating on Labels

Extra Heavy Caps and Tubing

Ampere Capacity Stamped in Fibre

Soldered Blades Perfect Alignment

Approved by the National Board of Fire Underwriters



Diehl Car Fans
FOR
Railway Car Service

They are the best. When the manufacturers could no longer improve the motor they improved the base. These bases are of artistic design and may be permanently mounted in the cars. The Fan is easily and quickly removed without disturbing its base. No marring of woodwork—no loss of time.

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or West. Prompt shipments are our
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Economy and Satisfaction

Follow the use of

Okonite Rubber Covered Wire

Okonite
and
Manson Tapes

For Insulating and Protecting Joints

OKONITE TAPE is a rubber insulated tape. Joints properly made with Okonite Tape are impervious to moisture and are as strong or stronger electrically and mechanically than the insulated wire itself.

MANSON TAPE is a rubber-filled cloth tape for protecting joints against mechanical injury. It is adhesive, does not unwrap, nor does it corrode copper wire. Is easily handled, economical to use.

Send for booklet, "Economy in Joint Making"

Gain 55% in Light
Save 20% in Power

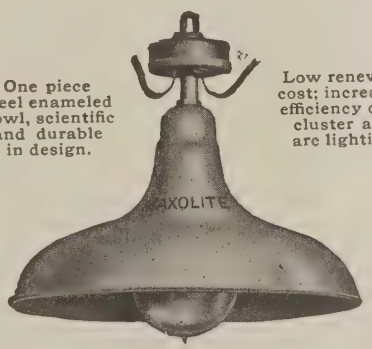
The Maxolite

Replaces Arc Lamps for Railway Shop and Yard Lighting

WRITE FOR BULLETIN NO. 41

One piece steel enameled bowl, scientific and durable in design.

Low renewal cost; increased efficiency over cluster and arc lighting



Bowl Type With Suspension Fitting

and SERVICE—then write us. We are largest stock of electrical supplies East specialty. If you have *not* our big instruct- asking. Write for it on your letterhead.

ric Company

of Service CHICAGO, ILL.

president of the company, presided in a very delightful manner and gave out some extremely cheering intelligence regarding the Employees' Beneficial Fund, which is now being set aside for the sole benefit of the employees.

CONSOLIDATED CO. MOVES CHICAGO OFFICE.

The Consolidated Electric Lighting and Equipment Company announce the removal of their Chicago office to room 1106 Karpen Building, 900 S. Michigan Avenue

U. S. L. NOTES.

The United States Light and Heating Company have just announced the appointment of the following officers:

Charles A. Starbuck, Chairman Board of Directors.
J. Allan Smith, President.
Frank P. Frazier, Vice-President.
William P. Hawley, Vice-President.
A. H. Ackermann, General Manager.

The company has experienced a very marked activity during the past year in the automatic electric starter and lighter business in addition to a large railway car lighting business. This has required a very large addition to their present plant at Niagara Falls, which is just about completed.

"OURSELVES AS OTHERS SEE US."

It isn't very often that we say much about ourselves, neither is it very often that Uncle Sam goes to the trouble and expense of purchasing a large number of copies of any trade journal to distribute among its employees for educational purposes.

The U. S. Railway Mail Service recently purchased 105 copies of our Postal Car Number in March for this purpose. This is one of the highest compliments ever paid the RAILWAY ELECTRICAL ENGINEER.

But it is the expressions of appreciation we are receiving from our readers continually that is the greatest source of satisfaction and here are a couple received since our last issue.

To the Editor:

Practically all the men in the employ of the L. V. R. R. at Sayre as axle-light men are subscribers to your magazine.

Most of the men depend entirely upon your sheet for direction in the absence of any real useful handbooks on axle-light systems. From the praise and pleasure heard on all sides you are evidently a vast help to our squad of fifteen men, particularly since you have begun your "A. B. C. of Car Lighting".

The L. V. R. R. Co. are the proud owners of no less than eight different axle-light equipments on a passenger equipment of somewhere in the neighborhood of 250 coaches, a condition which is decidedly an objectionable feature when maintenance and repair work are considered. However, it is a great educator to axle-light electricians, particularly where a man can become familiar with a variety of equipments through both study and practical experience. I believe you have explained in detail all the equipments we now have in operation and the help we have derived has been invaluable. Believing heartily in your magazine, I am enclosing a check for $2 for Mr. Cooper, one of our embryo engineers.

WILSON CRAWFOR, Jr.
Sayre, Pa., March 31, 1913. Lehigh Valley R. R.

To the Editor:

I have before me a copy of the April issue of the Railway Electrical Engineer, and it is such a model number in every respect that I feel you should be encouraged by a few words of appreciation.

Every page is alive with good solid and interesting matter, the composition throughout is excellent, the paper stock and press work is almost perfect, and the half-tone illustrations throughout are seldom excelled in higher class art publications and never in trade papers.

To those who know the problems that enter into the compilation and printing of a periodical, your April issue should be a model to pattern after.

Keep up your good work, and know that you are being appreciated by your readers, even though we don't always take the opportunity of saying so.

Very sincerely yours,

L. SCHEPMOES,
Publicity Agent.

The Safety Car Heating & Lighting Co.,
2 Rector Street.
New York, April 17th, 1913.

Twelve Stories of Solid Comfort in the Heart of New York City

Hotel York STRICTLY FIRE-PROOF

36th Street, corner 7th Avenue

Within Ten Minutes' Walk of 30 Leading Theatres, Shops, etc. One Short Block to Broadway.

Accommodations Better Than Rates Indicate

Attractive Rooms, $1.50 and $2.00, with Bath Privilege.
Attractive Rooms, $2.00 to $4.00, with Private Bath.
Where Two Persons Occupy Same Room, Only One Dollar Extra Added to Above Rates.

H. G. WILLIAMS, Manager

BALL ~ BEARINGS

HB DWF

The Hess-Bright Manufacturing Company

Pioneers in the introduction of Annular Ball Bearings

Most extensive resources and plants in existence devoted exclusively to ball bearing manufacture

Main Offices and Plant No. 2 on Main Line of Pennsylvania Railroad to New York

No. 47 East Erie Avenue, Philadelphia, Pa.

Do Not Forget

THAT this record has been made upon Hess-Bright Ball Bearings only.

All ball bearings are not capable of performing the severe service demanded of an axle generator.

Only the largest organization of its kind in the world, the finest materials available and the most careful co-operation both with the railroad and the manufacturer can meet the test.

Remember

THAT ball bearings have come to stay is generally admitted.

Their record of 100 per cent perfection for over two years is an indication of the long life that may be expected of them.

Generators that require bearing attention only twice a year, whose armatures cannot drop on the poles and whose electrical troubles are decreased 75 per cent are now available.

Specify Hess-Brights

HESS BRIGHT HB

HESS BRIGHT HB

If a Cyclone Can't Do It—What Can?

Not a damaged cell in the lot although the metal hood was crushed down on the battery, short-circuited it and burned off the "jumpers."

This Battery was in *That Car*

OMAHA VETERANS

It is no reflection on the car that it is part of the $25,000,000 loss from the recent tornado and flood

This electric roadster was buried under tons of brick when the Omaha "Electric Garage" was destroyed on Easter Sunday.

BUT AGAIN

The Edison Storage Battery is proved **"as rugged as a battleship." The Edison Storage Battery is not built for dainty handling, laboratory attention, cast-iron rules of service and "fair weather" conditions.**

Bulletin No. 1018 tells why a cyclone can't hurt it. It's a valuable story to those interested in train-lighting, railway signal service and self-propelled vehicles.

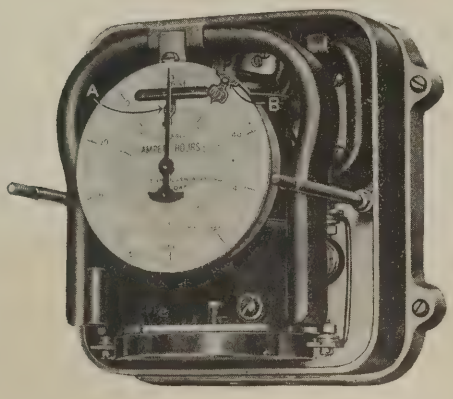
Edison Storage Battery Company

120 Lakeside Avenue :: :: **Orange, New Jersey**

Ampere Hour Meter Talk No. 6

All storage batteries require that more charge be put in than can be taken out—A 200 ampere hour discharge will require approximately 240 ampere hours charge to bring the battery up to full capacity.

The resistor type meter has been designed especially for car lighting work and automatically provides the necessary overcharge.

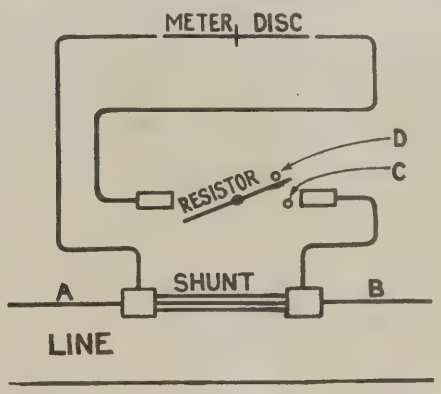


Meter with Case Removed

On discharge the dial hand moves slowly in a clock-wise direction, recording the ampere hour discharge. When the battery is charged, the direction of current flowing through the meter is reversed so the dial hand will move in the reverse direction. On charge, however, the meter travels about 20 per cent slower (for the same number of ampere hours) than it does on discharge. This provides for the proper amount of overcharge, as stated above.

By referring to the wiring diagram of the meter, it will be seen how this is effected. On charge, the resistor, which is simply a copper bar immersed in mercury and pivoted at the center, revolves through a slight angle causing the current shunted through the meter disc to pass through mercury at either end of the resistor bar.

Now, mercury has about sixty times the resistance that copper does, so causing the current to flow through this mercury is just like cutting in a low resistance. This cuts down the amount of current shunted



through the meter by about 20 per cent and so reduces the meter speed on charge accordingly.

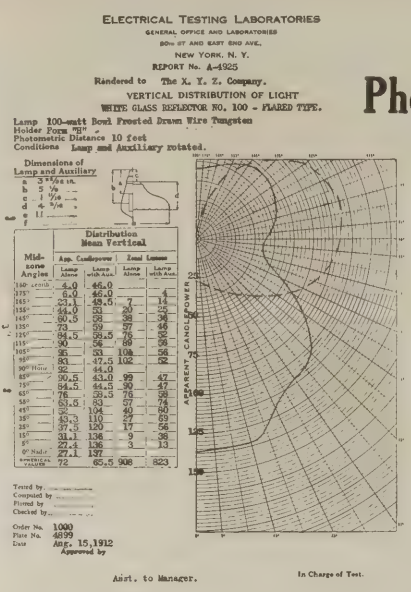
After the battery has been brought up to full capacity the indicating hand of the meter will come back to zero and make a contact at (A), which will stop further battery charging. After a slight discharge at the next stop the indicating hand will make another contact with the point (B), which will restore normal operation of the equipment.

The battery is operated for the most part over the "top" range of its capacity, with only occasionally a long discharge. This is very much like floating battery service where 10 years average life is experienced.

The resistor element of the meter being simply a copper bar floated in mercury adds no complication whatever to the meter, and the same robust construction which has given Sangamo Meters their great reputation for reliability and accuracy is employed in this meter.

Put one of these meters on a difficult run and convince yourself of its merits.

Sangamo Electric Company
SPRINGFIELD, ILLINOIS


ELECTRICAL TESTING LABORATORIES
GENERAL OFFICE AND LABORATORIES
80th ST AND EAST END AVE.
NEW YORK, N. Y.
REPORT No. A-4925
Rendered to The X. Y. Z. Company.
VERTICAL DISTRIBUTION OF LIGHT
WHITE GLASS REFLECTOR NO. 100 - FLARED TYPE.
Lamp 100-watt Bowl Frosted Drawn Wire Tungsten
Holder Form "H"
Photometric Distance 10 feet
Conditions Lamp and Auxiliary rotated.
Dimensions of Lamp and Auxiliary
Distribution Mean Vertical
Tested by
Computed by
Plotted by
Checked by
Order No. 1000
Plate No. 4899
Date Aug. 15,1912
Approved by
Asst. to Manager.
In Charge of Test.

The Photometric Curve

has become necessary for all illuminating engineering computations.

In order to make our services more valuable, a new photometric sheet has recently been designed for use in tests of this character, which presents not only the polar co-ordinate curve, but also the engineering data which makes the sheet complete for all engineering calculations.

Copies of a specimen report will be sent upon application.

Electrical Testing Laboratories
80th Street and East End Avenue
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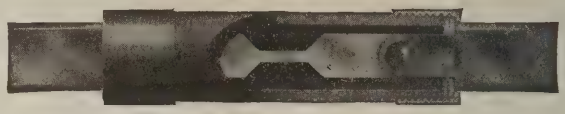
ECONOMY RENEWABLE CARTRIDGE FUSES



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I-T-E-Circuit Breaker

We do not always get in on these big railway installations at first. In these ten million dollar propositions the circuit breaker is a mere detail, it goes in with the rest of the equipment for a lump sum, but notice what happens. As these stock circuit breakers begin to give out, as they will, and the operating engineer begins to observe their faulty operation, as he does, what happens? They are gradually replaced and invariably with I-T-E.

Make a note of the fact that no job is too big for us to tackle and no problem too difficult for us to solve. I-T-E engineering is the best engineering there is—you can have it for the asking.

The Cutter Company
Philadelphia

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The Cutter Co.....Monadnock Block, Chicago, Ill.
The Cutter Co.....751 Ellicott Square, Buffalo, N. Y.
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WESTINGHOUSE MAZDA LAMPS

THE finishing touch to the equipment of the modern railway coach is the Mazda Lamp that makes the car cheerful and enables passengers to read in comfort.

WHY build an expensive car for the greater safety, convenience and comfort of your passengers and omit this important feature?

The modern Mazda Lamp—abundantly strong—has everything in its favor for train lighting.

It gives light for one-third the generator or storage battery capacity required by the carbon lamp.

A Westinghouse Mazda lamp will last twice as long as the carbon lamp.

Write for data on Westinghouse Mazda lamps in train lighting service. Our engineers have made a special study of train lighting requirements and their services are at your disposal.

Westinghouse Lamp Co.

Bloomfield, N. J.

Offices throughout the country

Factories—Bloomfield, N. J., and New York City

Shurlok

The Socket That Locks

would have prevented this accident due to a dark stairway where the lamp had been stolen. One personal injury claim, following an accident in an unlighted spot where the Shurlok—the socket that locks—would have kept the lamp in place, might entail greater expense than would be involved in equipping an entire system with the sockets that lock—Shurlok. Write for the catalog to-day.

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U. S. A.

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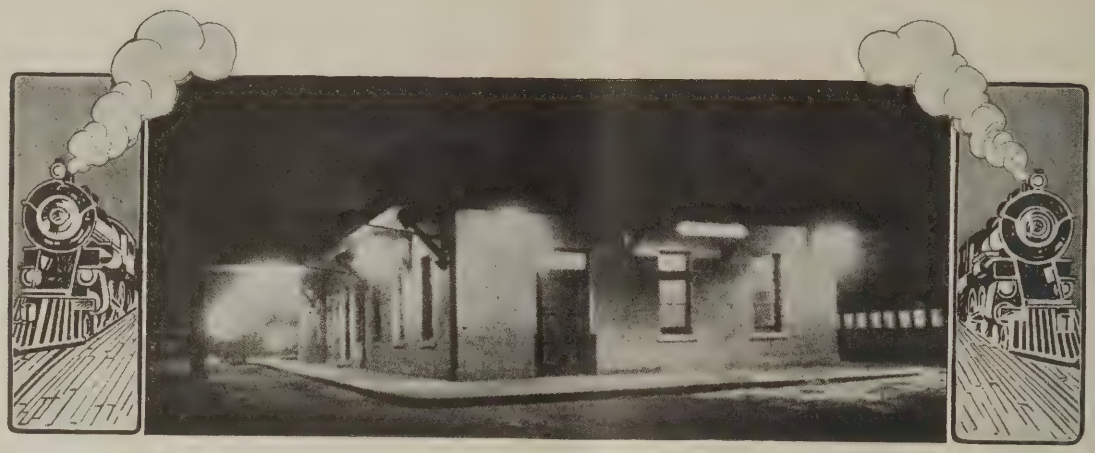

Brightly Lighted Stations Are Welcoming Beacons of Light

THE long, tedious hours of waiting at a station are made more tolerable if one can sit and read comfortably. Bright illumination points to progressiveness and creates an impression of "service" rendered.

While many improvements have been made in the interior lighting of the newer and larger stations, that of the smaller ones is still neglected in many cases. While waiting for trains how often the passenger finds it impossible to read without eye-strain or without assuming an uncomfortable position.

NATIONAL QUALITY MAZDA LAMPS

when substituted for the inefficient carbon lamps will triple the illumination without any additional current consumption. Where other methods of lighting are now employed, a well-planned installation of National Mazdas will greatly increase the efficiency and effectiveness of the illumination.

Consult our engineers in your lighting problems. Their services are free of charge.

NATIONAL QUALITY LAMP DIVISION

OF GENERAL ELECTRIC CO.

CLEVELAND, OHIO

AMERICAN ELEC. LAMP WORKS, Central Falls, R. I.
BANNER ELECTRIC WORKS, Youngstown, Ohio.
BRILLIANT ELECTRIC WORKS, Cleveland, Ohio.
BRYAN-MARSH ELECTRIC WORKS, Central Falls, R. I.
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THE COLUMBIA INC. LAMP WORKS, St. Louis, Mo.
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MUNDER ELEC. WORKS. Central Falls, R. I.
PACKARD LAMP WORKS, Warren, Ohio.
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STANDARD ELECTRIC WORKS, Warren, Ohio.
THE STERLING ELEC. LAMP WORKS, Warren, Ohio.
SUNBEAM INC. LAMP WORKS, Chicago, Ill.
SUNBEAM INC. LAMP WORKS, New York City.

Veluria Semi-Indirect Bowls

Eleven Designs—All Sizes

SEMI-INDIRECT lighting is very useful for the illumination of such spaces as station waiting rooms, dining rooms and for use in draughting departments where close work is done. The varied requirements of these installations are all met by one or more of our semi-indirect bowls. There are eleven designs which are furnished in all sizes.

Bulletin No. 106 gives complete data. Write for it.

HOLOPHANE WORKS

Of General Electric Company

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New York Boston Chicago Philadelphia San Francisco

7,000,000 Testimonials

Day in and day out, year after year, 7,000,000 Bell telephones give testimony to the reliability and high quality of

Western Electric Products

For more than 30 years the Western Electric Company has manufactured *all* the Bell telephones. This same company also furnishes equipment for every electrical need all as equally efficient and reliable as the "Bell" telephone.

When you want a motor, fan, wiring device, line material—in fact, anything electrical—order from the Western Electric distributing house nearest you.

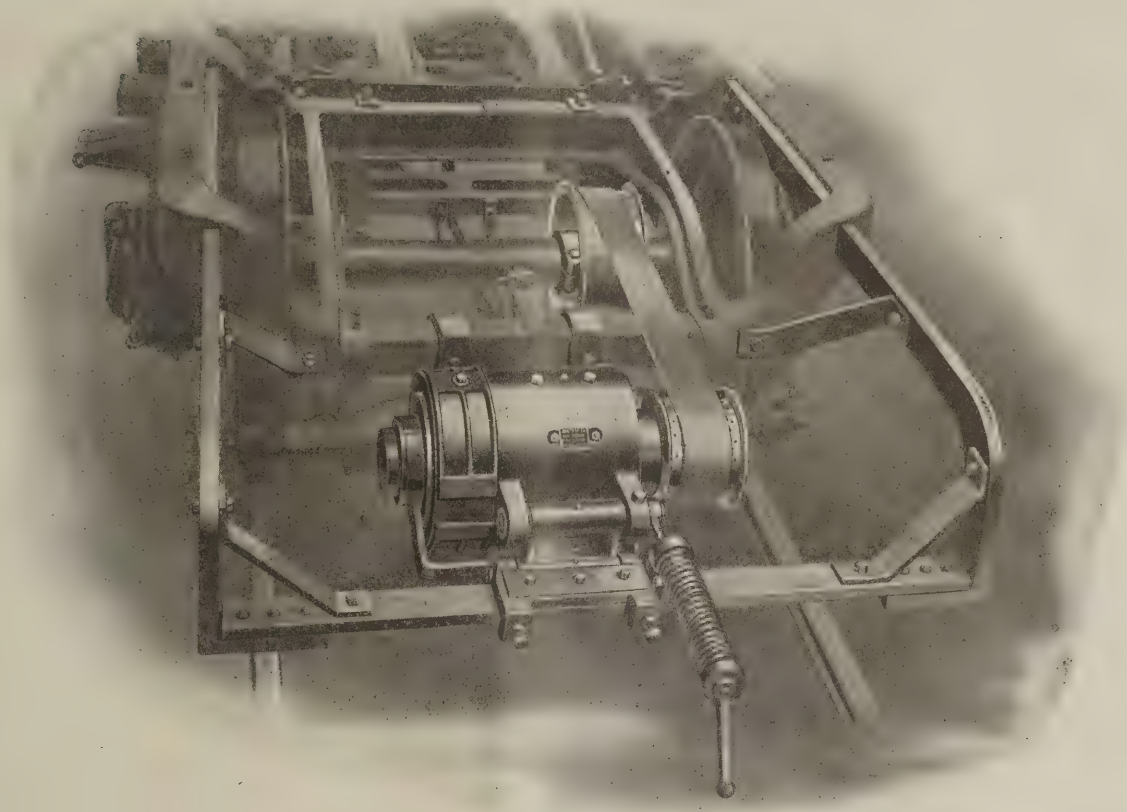
Western Electric Company

Manufacturers of the 7,000,000 "Bell" Telephones
Equipment For Every Electrical Needs

Main Office: New York City

Branch Houses: All Principal Cities

Safety Axle Generator Suspension



The Safety generator suspension is more easily adapted to various designs of car trucks than any other suspension.

All unfavorable features of generator suspension are eliminated, the advantageous parallel suspension is retained, and all parts are standard excepting the supporting irons, which have to be adapted to the various types of trucks.

The generator is entirely open for inspection and any part of same may be removed without any obstruction due to the suspension.

Very liberal wearing surfaces are provided on easily removable steel bushings with improved greasing facilities, reducing wear to a minimum.

The tension spring is so arranged with respect to the weight of the generator as to give a constant belt tension throughout the range of belt stretch.

The adjustment is so arranged as to prevent excessive belt tension through error or accident.

The generator is easily put in alignment with the axle.

The generator leads run to a terminal block so arranged as to make it impossible to connect them up wrong.

The Safety Car Heating & Lighting Co.

Chicago, Boston
Montreal
San Francisco

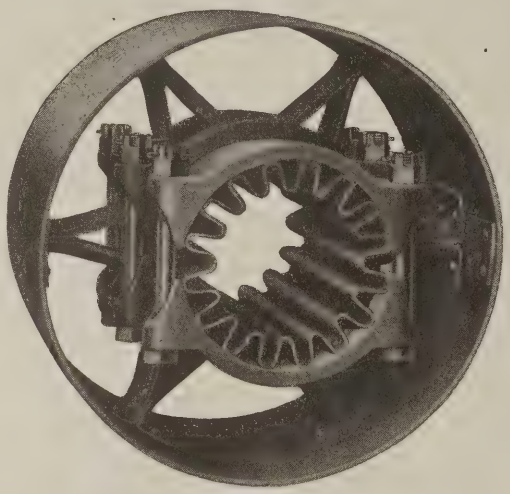
2 Rector Street, New York

Philadelphia
St. Louis
Washington

KEYSTONE
Railroad Axle Pulley

MANY THOUSANDS IN USE

Looks Good, Don't It

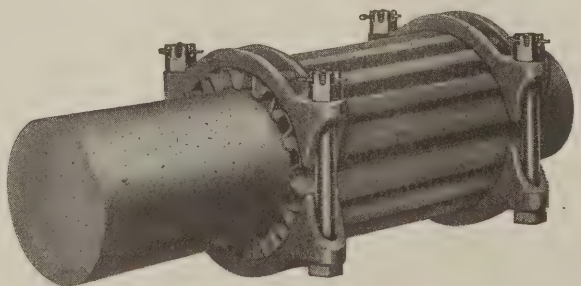


Keystone Railroad Pulley With Oneida Corrugated Bushing
Patented January 8, 1907

The Keystone Pulley with Oneida steel Corrugated Bushing

is the best combination for car axle lighting on the market.

Pulley made flange or flangeless. Standard 7½-in. bore, 16-in. to 23-in. diameter inclusive. Write for booklet.



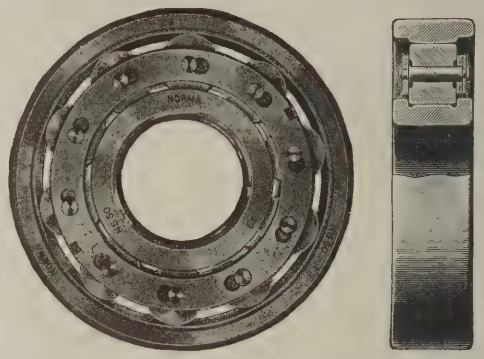
Oneida Corrugated Steel Bushing Made to Fit Straight or Taper Axle
Patented January 8, 1907

Oneida Steel Pulley Co.
ONEIDA, N. Y.

The Originators of Steel Railroad Pulleys and Steel Corrugated Bushings

NORMA ROLLER BEARINGS

For Axle Lighting Generators



The cylindrical shape of Norma Rollers gives them the maximum resistance to deformation, as well as permitting the most conclusive tests of their freedom from structural defects. Their diameter is tested to a precision of ± 1/10,000 of an inch.

Norma Rollers are guided at their center with perfect freedom and with the minimum of speed at the contact surface. This freedom permits them to adjust themselves to the position of least resistance in rolling, which is that in which their axes are parallel to the axis of the bearing. There is therefore no tendency to skew or bind or cramp.

The open type of the Norma Roller Bearing, and the design of the cage, permits the use of large rollers and many of them, meaning large load-carrying capacity. Because there is no thrust on the rollers, the duty of the cage is simply to maintain proper spacing of the rollers.

The curved outer race permits the Norma Roller Bearing to adjust itself under flexure or slight errors in alignment, without disturbing the correct relation of the parts and without loss of efficiency.

These are some of the Norma features explaining the fact that **Norma Roller Bearings have twice the load capacity of any ball bearing (size for size) and a 50 per cent overload capacity, with speed qualities and efficiency equal to those of any ball bearing.**

Bulletin 103.

The Norma Company *of* America

21 Vesey Street **NEW YORK**

Makers of
NORMA BALL BEARINGS

A New Axle Lighting Equipment

After a severe test in actual service the Atchison, Topeka & Santa Fe Railway Company has purchased 62 Axle Lighting Equipments of the type developed and perfected by The Electric Storage Battery Co.

This new Axle Lighting System involves a number of radical departures—among which may be mentioned:

A dynamo of the modified Rosenberg type giving constant voltage characteristic.
The elimination of the pole changer.
Regulation by a combination of circuits without any moving parts.
The elimination of the lamp regulator.
Automatic adjustment of dynamo output.
Elimination of useless overcharge of battery.

THE ELECTRIC STORAGE BATTERY CO.

MANUFACTURER OF

The "Chloride Accumulator", The "Tudor Accumulator"
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1888-1913

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50% More Efficiency

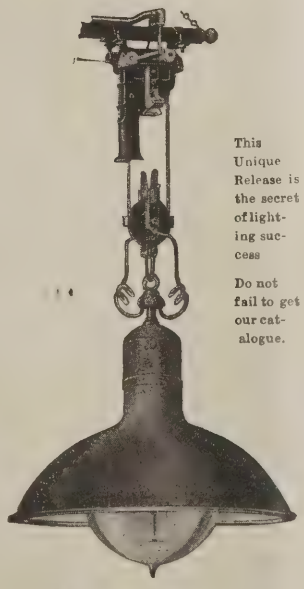
Clean reflectors double the amount of light you get.

The cost of cleaning may be great or small depending on means employed.

The Thompson Automatic
Cut-Out Hanger

allows the lamp to be lowered from any position without jar or jerk; where it can be cleaned by low priced help, in a position of safety.

Made also in larger size for Flaming Arcs



This Unique Release is the secret of lighting success

Do not fail to get our catalogue.

The Thompson Electric Co.

102 St. Clair St., N. W.

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A REAL LAMP

Excello-Dia
100-125 Hours

for Alternating Current Service 25-133 Cycles, two on 110-120 or 4 on 220-240 volts, white or yellow light. This is the latest development of the **"EXCELLO"** idea and embodies in its design and construction the results of years of experience in the production of the **"EXCELLO," the most efficient and the most reliable short hour flame Lamp** known to the American market.

The **EXCELLO-DIA** is of the best design, the best construction, and is absolutely reliable in operation.

Does not cast shadows.

Write for detail information.

KOERTING & MATHIESEN CO.

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YOU CAN SAVE

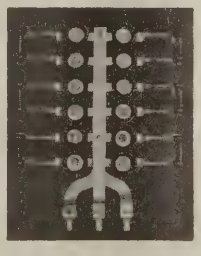
Time, Material and Space

By Using

CUTTER PANELBOARDS

The bus bars are mounted one above the other so that they occupy the space of only one bar on the face of the panel. The other bars occupy hitherto unused space and it is practically impossible to short-circuit a Cutter panelboard. The result of this construction is a reduction in the size of cabinet, linings and space required for mounting.

Cutter panelboards in all sizes and types are described and listed in catalog No. 12. Ask for your copy.



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425 Notre Dame Street **South Bend, Indiana, U. S. A.**

To Mount Electroliers or Combination Gas and Electric Fixtures on Exposed Conduit

Use Condulets of the "P" Series

APPROVED BY UNDERWRITERS

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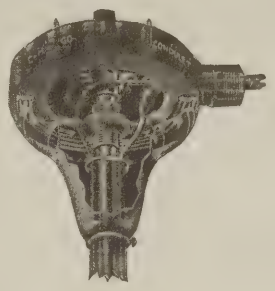
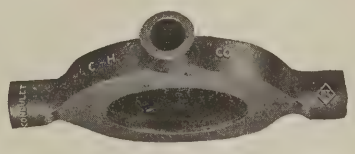
Strongest, Smallest, Neatest Outlet Boxes on the Market for this Purpose

Six Types, Each in Sizes to Fit ½, ¾ and 1 inch Conduits

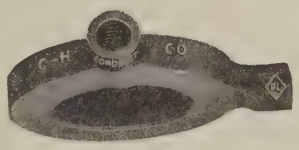


Type P, arranged for Combination Fixture



Type PT

Type PX



Type PL

Type PA

Type PC

There's a Special Condulet for Each Requirement, All Illustrated and Listed in Condulet Catalogs, Bulletins No. 100 and 101. Free on Request.

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SYRACUSE, N. Y., U. S. A.

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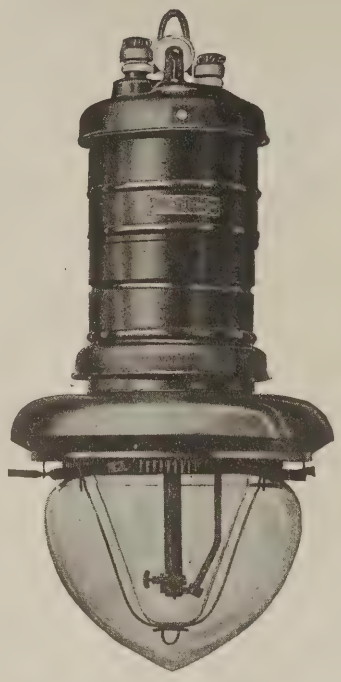

Multiple Long Life Flame Arc Lamp Type W

Adequate and Economical Illumination of Large Areas

This is accomplished by the G-E Multiple Long Life Flame Arc Lamp.

The lamp is especially designed for lighting train sheds, freight platforms, freight yards, etc., etc.

The illumination is powerful, steady, and very penetrating, the brilliancy remaining undiminished throughout the trim.

The maintenance cost of the lamp is very low as one set of carbons burns from 100 to 120 hours without attention and only one electrode needs renewing at each trim.

Although only a short time on the market the G-E Multiple Flame Arc Lamp has been standardized by one of the largest railroads in the country.

In hundreds of industries all over the country this lamp is giving the utmost satisfaction.

General Electric Company

Largest Electrical Manufacturer in the World

General Office: Schenectady, N. Y.

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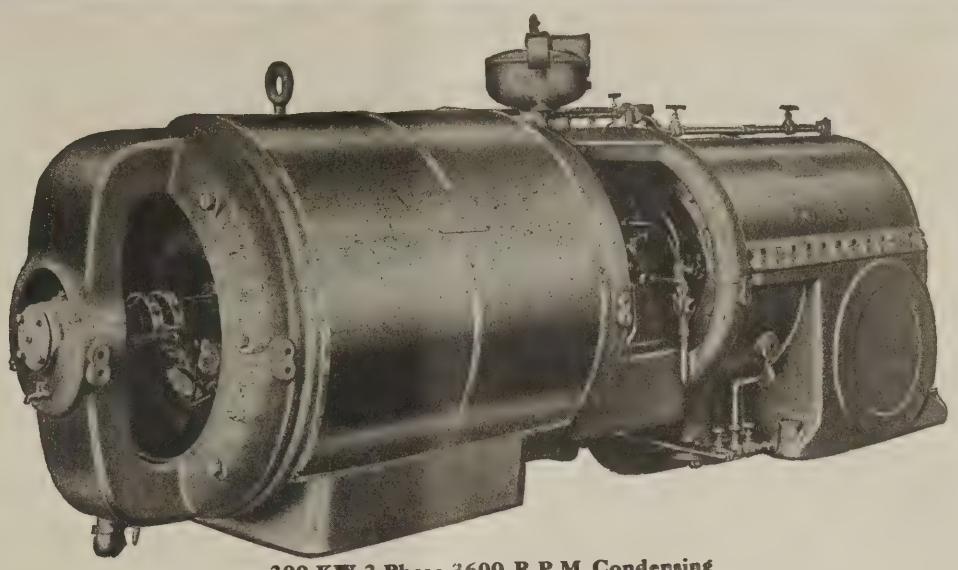
For Texas and Oklahoma business refer to Southwest General Electric Co., (formerly Hobson Electric Co.)—Dallas, El Paso, Houston and Oklahoma City. For Canadian business refer to Canadian General Electric Company, Lt'd, Toronto, Ont. 4121



300 KW 3 Phase 3600 R P M Condensing
Curtis Steam Turbine

CURTIS TURBINES
CLOSELY LINKED
RELIABILITY
ECONOMY

CURTIS TURBINES
CLOSELY LINKED
RELIABILITY
ECONOMY

Anticipate future business by installing adequate power-generating facilities. The high efficiency of

Curtis Steam Turbines

at partial loads renders them ideal for such an installation.

The sturdy construction and self-contained features reduce to a minimum maintenance and operating expense.

General Electric Company

Largest Electrical Manufacturer in the World
General Office: Schenectady, N. Y.
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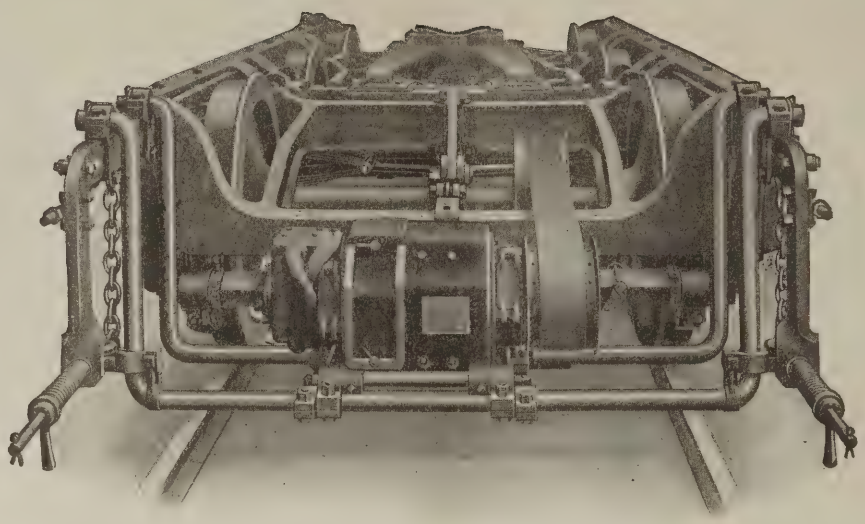

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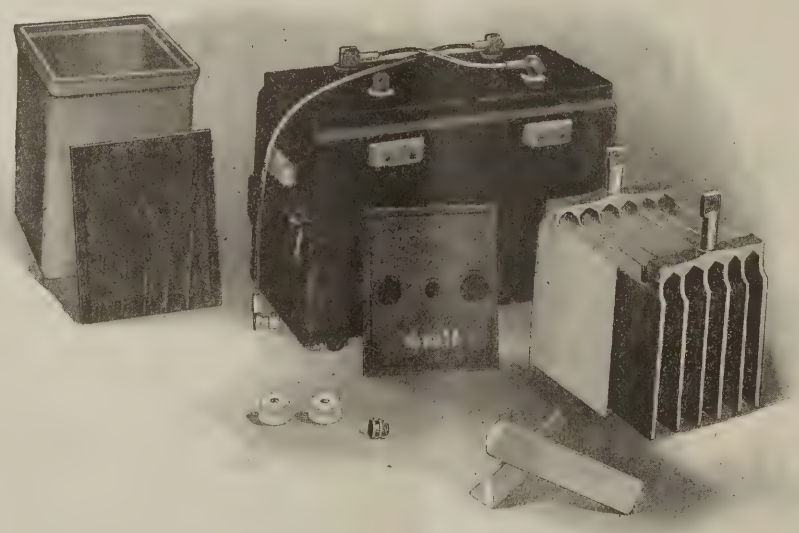

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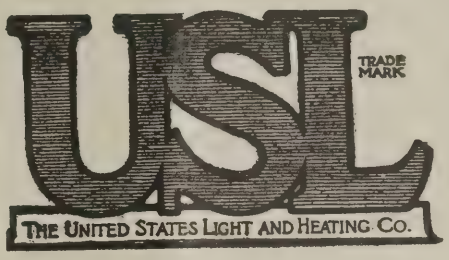

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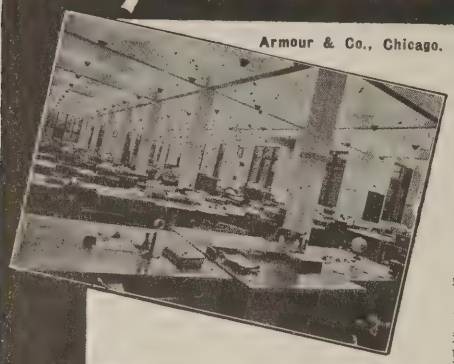

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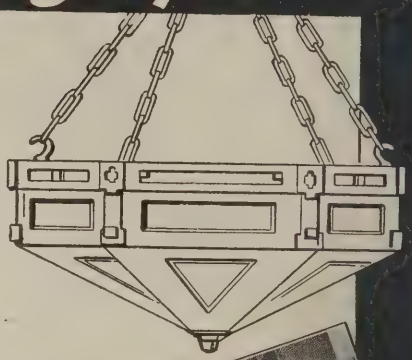
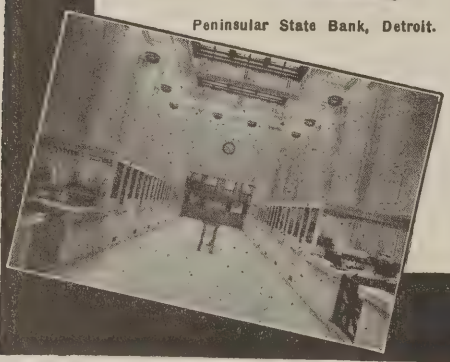


The Hub, Chicago.



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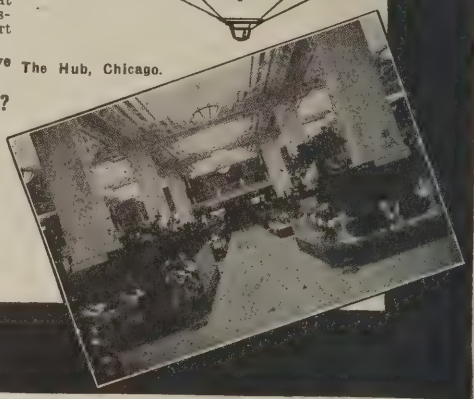

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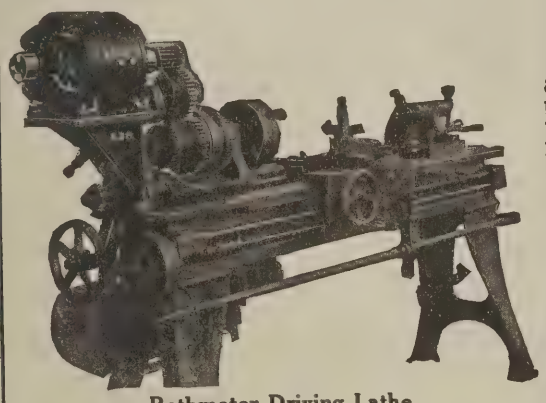

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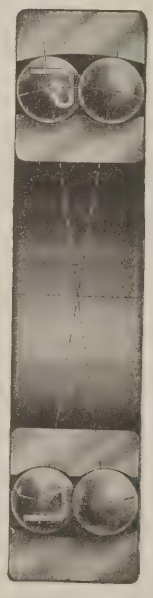

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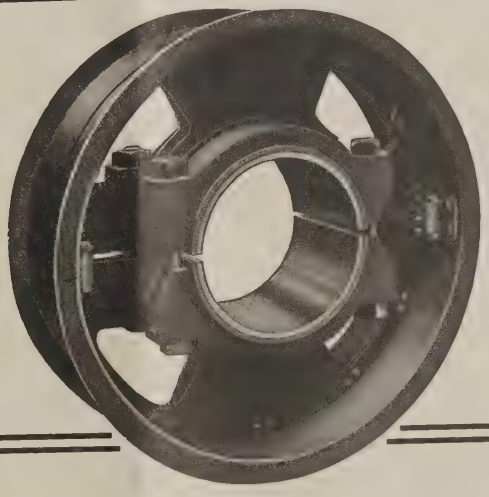

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